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PROBLEMS AND MANAGEMENT OF WATER QUALITY IN HILLSBOROUGH BAY, FLORIDA

Federal Water Pollution Control Administration
Tampa, Florida

December 1969

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PROBLEMS AND MANAGEMENT OF WATER QUALITY IN HILLSBOROUGH BAY, FLORIDA

U.S. DEPARTMENT OF THE INTERIOR
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Hillsborough Bay Technical Assistance Project
Technical Programs . . . . Southeast Region
Federal Water Pollution Control Administration
Tampa, Florida

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136

TABLE OF CONTENTS

Page No.

1. Introduction . . . 1
    - Previous Reports . . . 1
    - Objectives . . . 1
    - Scope . . . 1
    - Authority . . . 2
    - Acknowledgements . . . 2

2. Summary . . . 3

3. Conclusions . . . 5

4. Recommendations . . . 6

5. The Area . . . 7
    - Population . . . 7
    - Economy . . . 8

6. Physiography . . . 9
    - Geomorphology . . . 9
    - Sediments . . . 9
    - Climatology . . . 9
    - Hydrology . . . 10

7. Water Use . . . 12
    - Commerce and Industrial Uses . . . 12
    - Recreational Boating . . . 12
    - Swimming . . . 12
    - Fish . . . 12
    - Shellfish . . . 12
    - Aesthetics . . . 13
    - Applicability of State Standards . . . 13

8. Pollution Sources . . . 15
    - Municipal Wastes . . . 15
    - Industrial Wastes . . . 16
    - Tributary Streams . . . 16

9. Water Quality . . . 19
    - Dissolved Oxygen . . . 19
    - Nitrogen and Phosphorus . . . 23
    - Fecal Coliform . . . 25

10. Benthic Algae . . . 27
    - Method of Study . . . 27
    - Taxonomy and Physiology . . . 28
    - Reproduction and Growth . . . 28
    - Distribution . . . 29
    - Standing Crop . . . 29
    - Summary . . . 30

TABLE OF CONTENTS (Continued)

Page No.

11. Odor Production 33
  Water Quality in Odor Area 33
  Mechanisms of Odor Production 33
  Odor Surveillance Panel 35

12. System Simulation 37

13. Abatement 41
  Immediate Steps to Abate Odors 41
  To Meet Present Water Quality Standards 42
  To Establish a Diversified Ecology 42
  Rehabilitation 43

LIST OF FIGURES

Figure Number		Follows Page No.
5	THE AREA	
5.1	Area Foldout Map	86
6	PHYSIOGRAPHY	
6.1	General Ebb Current Pattern	10
6.2	General Flood Current Pattern	10
6.3	Precipitation Data	10
6.4	Wind Direction and Speed	10
6.5	Expected and Actual Tributary Discharge at USGS Gaging Station	10
8	POLLUTION SOURCES	
8.1	Major Waste Sources-Biochemical Oxygen Demand	18
8.2	Major Waste Sources-Filterable Residue	18
8.3	Major Waste Sources-Ammonia and Kjeldahl Nitrogen	18
8.4	Major Waste Sources-Total Phosphate	18
8.5	Major Waste Sources	18
9	WATER QUALITY	
9.1	Mean DO and BOD-Intensive II B-Main Channel Stations	22
9.2	Bottom Sediment Sampling Stations	22
9.3	Organic Carbon Distribution in Bottom Sediments	22
9.4	Mean DO and BOD-Intensive II C West Shore Stations	22
9.5	Diurnal DO Variations Station B3-Intensive II C	22
9.6	Mean Monthly Gross Photosynthesis Stations B1, B10, B12, B18, B22, B23	24
9.7	Monthly Mean Chlorophyll a Station B11	24
9.8	Phosphate Concentration	24
9.9	Ammonia Concentration	24
9.10	Mean Monthly Nitrogen Concentration-Station B3	24
9.11	Mean Monthly Nitrogen Concentration-Station B8	24
9.12	Organic Nitrogen Distribution in Bottom Sediments	26
9.13	Total Phosphate Distribution in Bottom Sediments	26
9.14	Fecal Coliform	26
9.15	Mean Fecal Coliform-Main Channel Stations	26
9.16	Mean Fecal Coliform-Alafia River	26
9.17	Mean Fecal Coliform-West Shore Stations	26
10	BENTHIC ALGAE	
10.1	Gracilaria Standing Crop, Beach Deposits and Wind Speeds on Western Shore	28
10.2	Annual Mean Gracilaria Crop	30
10.3	Gracilaria Standing Crop	30
10.4	Benthic Algae Transects	30
11	ODOR PRODUCTION	
11.1	Odor Panel Stations	36
11.2	Geological Distribution of Normalized Odor Index 1967-68	36
11.3	Monthly Distribution of Normalized Odor Index 1967-68	36

LIST OF FIGURES (Continued)

Figure Number		Follows Page No.
12	SYSTEM SIMULATION	

Figure Number		Follows Page No.
12.1	Hillsborough Bay Segments	38
12.2	Chloride Concentration in g/1, Dec., Jan., Feb., March 1967-68	38
12.3	Chloride Concentration, August, September, October 1967	38
12.4	Effect of Hillsborough River Discharge on Western Shoreline	40
12.5	Effect of Flow Diversion Proposal on Chloride Concentration Four River Basin Project	40

LIST OF TABLES

Table Number — Follows Page No.

5 THE AREA

5.1 Projected Population of Hillsborough County 7

6 PHYSIOGRAPHY

6.1 Expected Freshwater Discharges – Hillsborough Bay 11

7 WATER USE

7.1 Applicable Florida State Water Quality Standards 14

9 WATER QUALITY

9.1 Oxygen Utilized by Benthic Deposits 21
9.2 Primary Productivity Study 22
9.3 Seasonal Comparison of Total Phosphates 24

10 BENTHIC ALGAE

10.1 Benthic Algae Transect Description West Shore of Hillsborough Bay 27
10.2 Old Tampa Bay Transects – North to South – June 1968 31

11 ODOR PRODUCTION

11.1 Chlorosity and Water Quality Along the Western Shore of Hillsborough Bay 34

1.

INTRODUCTION

It has been reported as far back as 1928 that noxious odors have been occasionally present along the west shore of Hillsborough Bay. Residents and others familiar with the Tampa area have indicated that odors have occurred for at least 20 years and are worse now than ever before. During that time, the city of Tampa discharged raw sewage to Hillsborough River and Hillsborough Bay and local industries provided no treatment of their wastes. The odor problem occurred intermittently until 1951 when the city of Tampa constructed primary sewage treatment facilities on Hookers Point. Installation and operation of these facilities and subdued odors occurred simultaneously. In the early 1960's, however, the odors apparently intensified.

Previous Reports

At the request of the Commanding General of MacDill Air Force Base, the Florida State Board of Health conducted a study of Hillsborough Bay in 1944.(1) Their report published in 1964 concluded that, "1) odors were caused by the decomposition of marine animal life and the algae vegetation entrapping it when exposed to the air and sunlight as a result of being washed upon the beaches, and 2) the prevalence of vegetative material is slightly greater than found in salt water areas with similar physical and historical background."

This study revealed sulphur concentrations as high as 8,000 mg/dry gram of algae (presumably Gracilaria), and up to 900 mg/l of hydrogen sulfide in bottom muds. This report also found B.O.D., dissolved oxygen and concentrations of phosphate nutrients indicative of polluted conditions.

Subsequently, the city of Tampa Department of Public Works prepared a preliminary report and recommendations for reducing odors in the Bay near Bayshore Boulevard.(2) Four alternative procedures were discussed, three of which involved dredging along Bayshore Boulevard. The recommended procedure involved principally housekeeping activities along the seawall and the removal of loose silt from the Bay bottom. The report also recommended furthur detailed studies to determine the most satisfactory way to improve Hillsborough Bay. In 1965, the Federal Water Pollution Control Administration (formerly Division of Water Supply and Pollution Control, U.S. Public Health Service) received a request for technical assistance, initiated by the city of Tampa and forwarded through Congressman Sam Gibbons to the agency. The Florida State Board of Health made a similar request to the Southeast Regional Office. In August 1965 a reconnaissance of the area was made by agency personnel. At that time it was recommended that a technical assistance project be undertaken. The present study was initiated shortly thereafter and full scale field operations began on June 8, 1967. Since that time, a pattern of pollution, water quality degradation and a complex ecological system has been defined.

Objectives

Specific objectives of the Hillsborough Bay Technical Assistance Project were:

a. To identify and quantify key sources of waste in Hillsborough Bay and to determine their effects on water use.

b. To determine the cause, or causes, of noxious odors in Hillsborough Bay as requested by state and local authorities.

c. To recommend methods or means of modifying conditions in Hillsborough Bay to eliminate causes of obnoxious odors and make possible other desired uses.

Scope

To accomplish the stated objectives, a series of physical, chemical, biological and bacteriological tests were conducted between June 8, 1967 and August 1968 in Hillsborough Bay, its principal tributaries and adjacent land areas.

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(1)A Study of the Causes of Obnoxious Odors, Hillsborough Bay, Hillsborough County, Florida, Florida State Board of Health, Bureau of Sanitary Engineering, Jacksonville, Florida, January 1965.

(2)Proposals and Recommendations for Reducing Odors and Removal of Silt and Floating Debris in the Bay near Bayshore Boulevard, Hillsborough Bay, Department of Public Works, City of Tampa, Florida, May 1965.

Identification and evaluation of key waste sources required sampling each tributary stream as well as municipal and industrial waste sources. Determining the effects of these wastes on water use required water quality measurements throughout the Bay system involving the following special studies: water quality field surveys over several short periods of time to define equilibrium conditions; synoptic chloride and temperature studies; dye tracer and tidal current measurements; mapping and chemical characterization of benthic materials, and primary productivity studies.

Determining the causes of obnoxious odors involved identification of the causative agent; standing crop studies; comparison of Hillsborough Bay with Old Tampa Bay with respect to benthic algal populations and chemical parameters; closed system odor production laboratory tests and chloride tolerance tests of selected algal species.

Recommendation of abatement procedures required consideration and evaluation of a wide array of alternatives. These alternatives were evaluated using a mathematical simulation of the bay system to gain insights into the probable effects of the abatement actions on resultant water quality and environmental conditions.

Authority

Authority for this study is derived from PL 84-660 as amended by PL 89-753 (1966). Section 5B provides for technical assistance to the states.

Acknowledgements

The cooperation and assistance of the following agencies and individuals is gratefully acknowledged:

The City of Tampa Department of Sanitary Sewers and Mr. C.M. Courson, Treatment Plant Superintendent.

The Hillsborough County Health Department, Department of Sanitary Engineering and Mr. Don Rogers, Director.

The U.S. Geological Survey, Tampa District Office and Mr. Robert Murphy, Surface Water Division.

The Florida Department of Air and Water Pollution Control (formerly State Board of Health Division of Sanitary Engineering) and Mr. K.K. Hufstutler, Engineer in Charge, Winter Haven Regional Environmental Facility, Winter Haven, Florida.

The Tampa Port Authority.

2.

SUMMARY

The residents of the city of Tampa have reported obnoxious odors along the western shore of Hillsborough Bay for many years. This odor had historically been associated with excessive growths of attached algae and general poor water quality attributable to waste discharges. At the request of local authorities and the Florida State Board of Health, FWPCA initiated extensive field and laboratory investigations in Hillsborough Bay in June 1967. The objectives of these studies were: to identify and quantify key sources of waste in Hillsborough Bay and to determine their effect on water use; to determine the cause or causes of noxious odors in Hillsborough Bay and; to recommend means of modifying conditions in Hillsborough Bay to eliminate the causes of obnoxious odors and make possible other desirable uses.

Sixty-eight municipal and industrial waste sources were identified and investigated. The major contributor of carbonaceous organic material to Hillsborough Bay is the primary sewage treatment plant of the city of Tampa which discharges about 28 million gallons per day at the southern tip of Hookers Point. This effluent contains carbonaceous organic material equivalent to a population of 290,000 and represents more than 85% of all carbonaceous waste from point sources. The plant is also the major contributor of unsatisfied nitrogenous material, discharging 7300 pounds per day or more than 40% of the total input to the Bay from point sources. The other major contributors of pollution to the Bay are the MacDill Air Force Base sewage treatment plant, U.S. Phosphoric Products Company, Nitram Chemical Company, Palm River (Sixmile Creek), Hillsborough River and the Alafia River. The Alafia River which has fourteen phosphate processing plants near its headwaters contributes more than 43,000 pounds per day (as phosphorus, P) or 78% of the total phosphorus input to Hillsborough Bay from point sources. U.S. Phosphoric Products and the Alafia River contribute 94% of the total phosphorus. The Alafia River, Nitram Chemical Company and U.S. Phosphoric Products together discharged nearly 50% of the total unsatisfied nitrogenous material to the Bay. Another major source of nitrogen and phosphorus to Hillsborough Bay at intermittent periods during the survey was the flushing of water hyacinths from the Tampa water supply reservoir down the Hillsborough River.

Dissolved oxygen in the ship channel between Davis and Seddon Island was continually less than 4 mg/l, the official Florida criterion, during warm weather months. Concentrations near the bottom of the channel were essentially zero during these periods. Although dissolved oxygen averaged greater than 4 mg/l at the five foot level in most of the Bay during warm weather, there were extremely pronounced daily fluctuations above and below this figure. Sixteen percent of the bottom area of Hillsborough Bay contained greater than 3% organic carbon content by weight. Those bottom areas of Hillsborough Bay highest in organic carbon content share three similar characteristics: they are generally contiguous to waste inputs; they occur in areas where tidal currents are lowest; they occur extensively along the western shore where the odor problem is reported.

The highest values of phosphate were observed in the Alafia River and averaged 9.65 mg/l.* The minimum concentration was 1.65 mg/l at the mouth of the Bay. These concentrations are from 55 to 322 times above the levels necessary to support accelerated eutrophication or premature aging of an estuary. Ammonia concentrations in the Bay averaged between 0.16 mg/l and 0.45 mg/l. Available nitrate concentrations follow a seasonal pattern of being low in the warm weather months (0.01 mg/l) and high in the cool weather months (0.15 mg/l.) This pattern results from the uptake of available nitrates by the plant life in the Bay.

Based on chlorophyll determinations, Hillsborough Bay supports a phytoplankton population about four times greater than Tampa Bay primarily due to the excessive concentrations of total nitrogen and phosphorus in Hillsborough Bay. Gracilaria is the benthic algae which proliferates along the western shore of the Bay. In Hillsborough Bay, Gracilaria makes up 98% of the attached algal crop while in Old Tampa Bay it accounts for only 2%. Old Tampa Bay exhibits a diversified population of plant species which is indicative of a healthy ecosystem.

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*All phosphorus is reported in mg/l as P and all nitrogen compounds are reported in mg/l as N.

Hillsborough Bay does not support a diversified population of plants. Field and laboratory evaluations have shown that Gracilaria is tolerant to turbid water and degraded water quality.

When chloride concentrations along the western shore decreased to less than 6 g/l due to freshwater from the Hillsborough River amounting to more than 2400 cfs, the Gracilaria standing crop was substantially reduced; dissolved oxygen was depleted and sulfides were produced. An odor panel consisting of residents along the western shore and initiated by the Project reported intense odor during this period. Laboratory tests confirmed the sensitivity of Gracilaria to reduced chlorosity. These tests also indicated that the presence of sewage did not aggravate odor production as long as chloride concentrations exceeded 6 g/l.

3.

CONCLUSIONS

Obnoxious odors along the western shore of Hillsborough Bay are the result of the death and decay of the marine algae, *Gracilaria*. There are two odors: a nauseating vegetative odor occurring predominantly at MacDill Air Force Base from *Gracilaria* deposited on beaches and shorelines and; an intense hydrogen sulfide odor occurring predominantly along the upper western shore north of MacDill as a result of anaerobic decay of *Gracilaria* in shallow waters. The immediate causative agent in the death and decay of the benthic algae is freshwater from the Hillsborough River part of which is diverted along the western shore during high flow periods primarily occurring during August and September. When freshwater flow in the Hillsborough River exceeds 2,400 cfs, chloride concentrations along the western shore are reduced below 6 g/l which is the salinity stress point for *Gracilaria*. Poor flushing along the western shore tends to keep the chloride concentration reduced thereby accelerating the death process. Dissolved oxygen is used up during decay of the *Gracilaria* and hydrogen sulfide is produced.

Waste discharges from point sources do not produce the odor problem directly. In fact, *Gracilaria* is tolerant to degraded water quality. However, waste effluents and excessive nutrient concentrations create the water quality conditions whereby *Gracilaria* can flourish at the expense of a number of other plant species that would produce a healthy diversified ecosystem if water quality were improved. Therefore, the contribution of nutrients and organic wastes to Hillsborough Bay is the ultimate cause of the obnoxious odors along the western shore of Hillsborough Bay.

The excessive growths of phytoplankton in the Bay are primarily the result of the extremely high concentrations of phosphate and higher than desirable concentrations of total nitrogen in the Bay. The cause of these concentrations is the effluents from the phosphate processing plants on the Alafia River, the Tampa sewage treatment plant, U.S. Phosphoric Products Company, the Nitram Chemical Company and water hyacinth control practices. Because of the massively excessive phosphate concentrations, it is concluded that the biological plant system is limited by available nitrogen. A high percentage reduction of available nitrogen as well as phosphorous will limit the growth of aquatic vegetation.

Low dissolved oxygen in Hillsborough Bay is the result of the discharge of inadequately treated effluent from the city of Tampa sewage treatment plant. There is also a substantial demand on the oxygen resources of the Bay from organic benthic material which accounts for the excessively low dissolved oxygen values at the deeper levels. The principal sources of these benthic deposits are the solids inflow from the Hillsborough and Alafia Rivers, the discharge of the Tampa sewage treatment plant and the settling of phytoplankton and other organisms.

Although water contact recreation activities are feasible in many parts of the Bay, presently degraded water quality caused by untreated and inadequately treated waste sources listed above, preclude these desirable uses.

4.

RECOMMENDATIONS

A water quality management plan and waste abatement program for Hillsborough Bay to eliminate the causes of odors, improve water quality, restore a diversified ecosystem, control accelerated eutrophication, and make possible additional desirable water uses, should include the following measures in order of priority:

(1) The water use classification of Hillsborough Bay south and west of Davis Islands should be immediately upgraded to class III: Recreation and Propagation of fish, by the Florida Department of Air and Water Pollution Control.

(2) Fresh water discharge from the Hillsborough River should not exceed 2000 cubic feet per second (cfs). Adequate facilities to meet this requirement should be provided by the Southwest Florida Water Management District and the U.S. Army Corps of Engineers in the Hillsborough River phase of the Four Rivers Basin Project.

Storm sewers along the western shore should be extended by the city of Tampa to the 3½ foot depth (mean low water) to reduce the effects of this localized source of fresh water.

These measures will maintain chloride concentrations along the western shore greater than the level below which Gracilaria are killed and odors are subsequently produced.

(3) An overall removal of ninety percent total nitrogen and ninety-nine percent total phosphorus presently being discharged to Hillsborough Bay and its tributaries from the Tampa sewage treatment plant, U.S. Phosphoric Products Company, Nitram Chemical Company and phosphate processing plants on the Alafia River should be accomplished.

(4) Secondary sewage treatment to remove at least ninety percent of the carbonaceous waste material and effective year round disinfection should be provided at the Tampa sewage treatment plant and the MacDill Air Force Base sewage treatment plant.

(5) A master plan for dredging and filling in Hillsborough Bay should be developed by the pertinent Federal, state and local operating and regulatory agencies. Certain spoil islands, resulting from channel dredging, which impair circulation, flushing and exchange in the Bay, should be removed and maintenance spoil dredging material should not be deposited in the Bay. Selective dredging of the more extensive organic benthic deposits should be accomplished. This master plan can be formulated through the use of mathematical and hydraulic models of the Bay system which have already been developed or authorized.

(6) An engineering feasibility study of an area wide collection system for all wastes tributary of Hillsborough Bay should be accomplished. The wastes, after receiving recommended treatment, should either be discharged to a remote disposal site in the upland headwaters of the tributary system to serve as recharge for ground water reserves (reuse) or, to an outfall for disposal at a suitable site in the Gulf of Mexico.

It is recognized that these recommendations for a permanent solution to the problem of odors, poor water quality and ecological imbalance in Hillsborough Bay will require a time for implementation. Immediate short term temporary control measures should be taken to limit the occurrence and intensity of odors. These include 1) removing, from the western shore, all aquatic vegetation and miscellaneous debris; 2) mechanical harvesting and remote disposal of Gracilaria; 3) the construction of temporary fencing in shallow water to make harvesting more efficient and keep material from the beachfront.

Hyacinths, a major source of nutrients, should not be discharged to the Bay from the Tampa water supply reservoir. A program of mechanical harvesting and remote disposal for hyacinths should be initiated at the reservoir.

5.

THE AREA

Tampa Bay is located near the center of the peninsular Gulf coast of Florida and is a complex system of adjoining Bays and estuaries including Boca Ciega Bay, Manatee River estuary, Tampa Bay, Old Tampa Bay, Hillsborough Bay and McKay Bay. Hillsborough Bay is a natural arm of Tampa Bay approximately eight miles long and four miles wide with two major freshwater tributaries. It is separated from Old Tampa Bay by the Interbay Peninsula and is bounded on the west and north by the city of Tampa. McKay Bay is a small shallow arm of Hillsborough Bay situated at the northeastern end of the larger body. A foldout map of the area is located at the end of the report.

Davis Islands are man-made islands situated in the northern part of Hillsborough Bay which were filled during the Florida land boom of the early 1920's. Davis Island is one of Tampa's finest residential areas and the site of many professional offices and of Tampa General Hospital. Seddon Island is privately owned and is developed as a rail switching yard and phosphate terminal. Hookers Point, a natural peninsula which has been improved and developed, is the site of most of Tampa's heavy industry and port terminals. Port Sutton is a privately financed port facility on the northeastern side of Hillsborough Bay and features sulfur, scrap iron and phosphate terminal facilities and Tampa's largest steam-electric generating plant. The eastern shore of Hillsborough Bay, south of Port Sutton, is largely undeveloped except for a phosphate products plant near the mouth of the Alafia River. Bayshore Boulevard, Ballast Point and MacDill Air Force Base front the Bay on the eastern shore of the Interbay peninsula.

The topography of the Hillsborough Bay watershed is characteristic of coastal lowlands and central Florida highlands. The area has nearly level plains near the Bay with gently rolling areas near the headwaters. There are numerous ponds, swamps and marshes as well as lakes and perennial streams. The largest lake in the basin is Lake Thonotosassa with a surface area of about 824 acres.

The Hillsborough River rises in the Green Swamp area of Central Florida and flows generally southwesterly for 55 miles to the northern end of Hillsborough Bay. Flow in the river is sustained by Crystal Springs in its headwaters and by Sulfur Springs and several other small springs in the lower reaches. The river flows through the city of Tampa and is the city water supply.

The Alafia River rises in western Polk County in a myriad of small creeks which form the North Fork and South Fork. These two branches join in east central Hillsborough County and flow westward to join Hillsborough Bay at Gibsonton. The highest land elevation is approximately 300 feet in southern Pasco County in the Hillsborough River basin.

Population

The population of the city of Tampa was estimated by the Chamber of Commerce to be 350,000 in 1961.(3) A population of 600,000 is estimated by 1980.

Hillsborough County had a 1960 population of 397,000. Population projections shown in Table 5.1 show an anticipated population of 604,300 by 1980; 943,000 by 2000; and 1,317,000 by 2020. These figures, prepared by FWPCA, are more conservative than those projected by the Florida State Board of

**Hillsborough Bay Technical
Assistance Project**

Table 5.1

**PROJECTED POPULATION
OF HILLSBOROUGH COUNTY**

Year	FWPCA Estimate	FSBC Estimate(*)
1960	397,900	397,900
1980	604,300	820,000
2000	943,035	-----
2015	-----	2,050,000
2020	1,317,000	-----

(*)Florida Land and Water Resources – Southwest Florida, Florida State Board of Conservation, Tallahassee, Florida, 1966.

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(3)"A Planning Report for Tampa Florida," 1961. Obtained from Greater Tampa Chamber of Commerce.

Conservation which estimates 820,000 by 1980; 2,050,000 by 2015. In either case, it is reasonable to assume a continued steady growth of Hillsborough County and the Tampa metropolitan area. As Tampa is bounded on the west and south by water, this expansion must progress to the north and east. Pressures of expanding population will undoubtedly lead to the further development of the eastern shore of Hillsborough Bay particularly that portion south of the Alafia River.

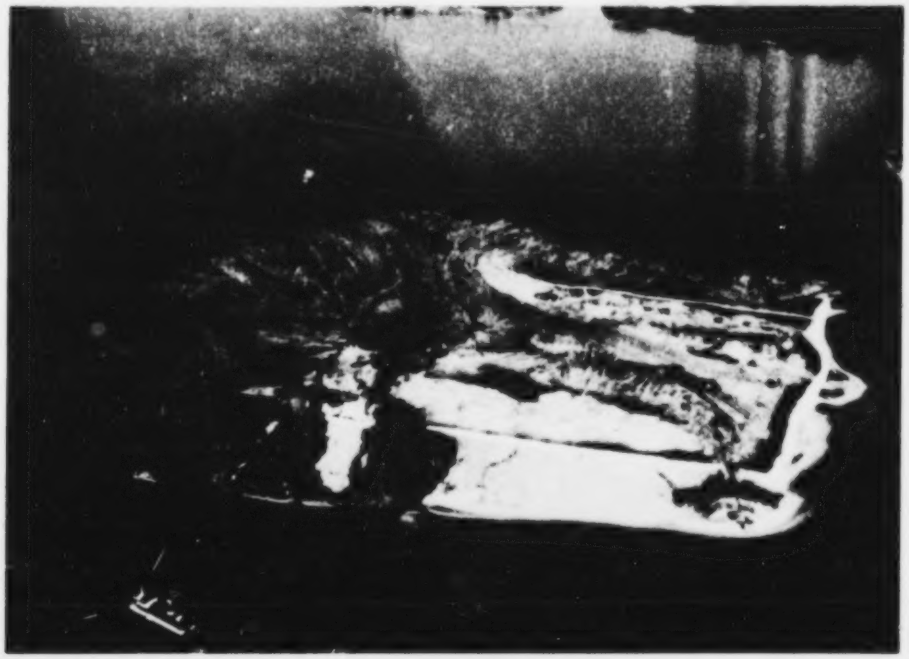
Economy

Tampa is the industrial center of southwest Florida. During the past three years, 92 new industries representing $44,481,775.00 in new capital investment have established themselves in Tampa.(4)

In 1967, a total of 25.9 million tons of water borne commerce passed through the port of Tampa. The principal commodity group was phosphate and phosphate products which accounted for 12.1 million tons followed by petroleum products which accounted for 6.1 million tons. The remainder was made up in lesser amounts of sulfur, coal, shell, gypsum, grains, cement and produce. Phosphate and phosphate products account for 95.33 percent of outbound cargo, much of which goes to foreign export. Petroleum, on the other hand, is principally an inbound movement, largely from domestic ports. The port of Tampa has in the past twenty years experienced phenomenal growth from a total water borne commerce rate of 3.7 million tons per year in 1946 to the present 25.9 million tons per year, an increase of 700 percent.(5)

Port related commerce and the attendant transshipment and distribution of that commerce is today the most significant economic factor in the Tampa metropolitan area. All of the port facilities are located north of a line between Port Sutton and the southern end of Davis Island.

It is estimated by the Tampa Port Authority that the tonnage rate will increase to a level of 47.5 million tons per year by the year 2000, of which 40 million tons will be equally divided between phosphate and petroleum products. As a result, the Port Authority expects private capital in excess of $31 million to be invested in a new phosphate handling complex.(6)



Spoil islands, resulting from channel dredging, impair circulation, flushing and exchange of the Bay.

(4)"Tampa Facts," Greater Tampa Chamber of Commerce, 1968.
(5)"Annual Report," Tampa Port Authority, 1967.
(6)"Annual Report," Tampa Port Authority, 1967.

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6.

PHYSIOGRAPHY

Geomorphology

Hillsborough Bay is a shallow arm of Tampa Bay approximately eight miles long and four miles wide with a maximum natural depth of 28 feet. Improved channels are maintained at 34 foot depths. The surface area of Hillsborough Bay, including the harbor area, Port Sutton, and McKay Bay, is 39.6 square miles and the total volume is 8.3 x 10^9 cubic feet at mean low water. Shoreline slopes are gentle except at bulkheads, with the 6-foot depth contour extending some 400 yards off the western shore and about 1200 yards off the eastern shore. Bottom configuration has been altered markedly by channel dredging and placement of spoil.

Tides are of the mixed type having one strong flood and ebb per day with an intermediate phase which may be either flood or ebb. The diurnal tidal range is 2.8 feet and the mean level is 1.4 feet. The tidal prism calculates to 3.1 x 10^9 cubic feet or approximately 31.5 percent of the volume of the Bay at mean tide. The average depth of the Bay at mean tide is 8.95 feet.

Currents

To supplement published tidal current predictions and unpublished data from a study made by U.S. Geological Survey in the summer of 1963, a program to measure tidal current was undertaken by this project in August 1968. Twenty-four stations were selected, primarily in the shallow areas where no previous data were available. Measurements were made within ±1 hour of the predicted maximum current. Results of the study are shown in Figures 6.1 and 6.2. The four stations at the mouth of the Bay show the expected near northward flooding. However, with the intervention of the Alafia River spoil banks, current directions become erratic, raising the possibility of several circular currents. There appears to be a small clockwise current pattern at the western end of the Alafia Channel although velocities are too weak to be conclusive. Flood tide waters moving up the center of the Bay are diverted westward along the southern end of Davis Islands and set up a clockwise circulation between Davis Islands and Bayshore Boulevard. Flood currents in the eastern half of the Bay are too weak and erratic to be conclusive as to direction or pattern.

Ebb currents indicate that the flow is divided on either side of a shoal lying between Ballast Point and Davis Islands, producing a current which sweeps southward along lower Bayshore Boulevard. Similar action would be expected at Long Shoal.

Dye tracer studies were conducted during the summer of 1968 when the flow of the Hillsborough River was approximately 2600 cfs and the Bay exhibited salinity stratification. In one series, 98.5 percent of the dye was accounted for in synoptic mass calculations two hours after release. This study indicated that 75.6 percent of the flow from Hillsborough River on ebb tide goes down Seddon Channel and the remaining 24.4 percent is diverted around the northwestern side of Davis Islands. The movement of dye through the Bayshore area tends to hold close to the seawall. At one station near the foot of the Bay to Bay Boulevard, the dye accumulated and persisted in measurable concentrations for at least 21 hours.

Water movements demonstrated by tidal current and dye tracer studies confirm that tidal currents in the Bay are weak and variable, but they also demonstrate the mechanism by which free floating material may be carried to and deposited in pockets along Bayshore Boulevard. The flood tide circulation between Davis Islands and Bayshore Boulevard creates a dead pocket at the foot of Bay to Bay Boulevard and on the north side of Ballast Point. The southerly sweeping ebb current produces dead pockets on the north side of Ballast Point and along MacDill Air Force Base north of Catfish Point. Each of these areas has been observed to be collection points for trash and floating debris.

Climatology

The climate of the Tampa Bay area is characterized by long, warm and humid summers and mild, dry winters. Daily maximum temperatures average near 90°F from June through September and temperatures of 100°F are not unknown in the coastal areas. In winter, daily temperatures vary widely with daily maximums averaging around 70°F and daily minimums averaging around 48°F. Occasional severe cold weather may bring temperatures into the 20's, but these cold waves seldom last more than two days.

The Tampa Bay area receives about 49.5 inches of rainfall per year of which 60 percent, or 30 inches, occur in the summer months of June through September. Figure 6.3 shows the monthly expected precipitation based on 36 years of record at the Tampa International Airport station (1931 through 1967), and the actual monthly precipitation for the period of study. The winter and spring of both 1967 and 1968 were dryer than normal. The first six months of 1967 had a deficit of 8.32 inches or 40 percent of the expected rainfall. July and August each had an abundance of rain; a combined total of 20.64 inches compared to an expected 16.17 inches, a 28 percent excess. However, from September 1967 through September 1968, only two months, December and July, had as much precipitation as expected. The winter and spring of 1968 had a deficit of 9.44 inches or 62 percent of the expected rainfall.

Wind direction and velocity are shown in a series of tables extracted from U.S. Weather Bureau records (Figure 6.4). These tables show that the predominant wind directions during the winter months (December, January, February) are north and south. From April through August, the east-west winds predominate. In September, they gradually shift to the northeast quadrant and remain through December.

Hydrology

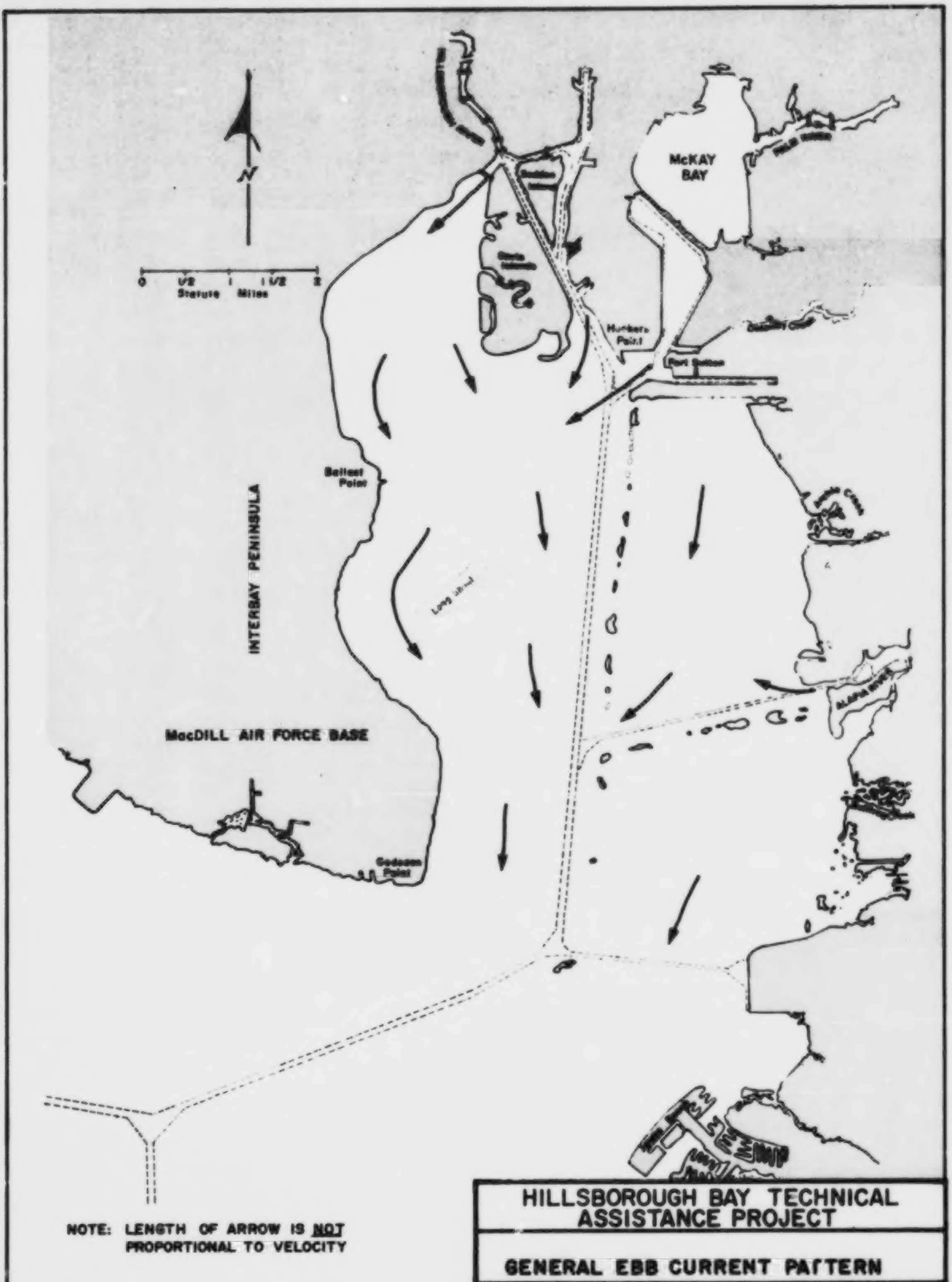
Three tributary streams discharge freshwater to Hillsborough Bay: Hillsborough River, Alafia River, and Palm River (Sixmile Creek). Probable discharges for each month for each tributary, Table 6.1, are based on all flow data for the period of record prior to 1960. The table shows the most probable mean monthly flow, the mean monthly flow which is expected less than 10 percent of the time, and the mean monthly flow which is expected less than 90 percent of the time.

The Hillsborough River is normally the largest source of freshwater to Hillsborough Bay. The last downstream gaging station is located at the Tampa Water Supply reservoir dam at approximate river mile 10.0. The drainage area above this point is 630 square miles. Appendix Table A.2 shows the expected monthly mean discharge at the gage, the actual discharge and the percentage ratio of actual to expected flow for January 1967 through September 1968. With the exception of February 1967 (115.4 percent of expected), the winter and spring of 1967 were extremely dry with less than five percent of the expected flow in three consecutive months (April, May and June). This was followed by a peak flow of 2300 cfs (219 percent of expected) in August and another nine months of below normal flow from September 1967 to May 1968. An additional 60 square miles of drainage area and Sulfur Springs are tributary to the river below the water supply reservoir. Therefore, flow measurements at the gage were corrected to provide a more accurate estimate of the fresh water input to the Bay. The corrected flow figures are shown in the final column of Appendix Table A.2.

The Alafia River has a total drainage area of approximately 460 square miles of which 335 square miles are tributary above the U.S. Geological Survey gage at Lithia. Two major tributaries, Fishhawk and Bell Creek, enter below that gage. The same procedures previously described were followed for correcting flow measurements in the Alafia River (Appendix Table A.3). In contrast to the low flows in the Hillsborough River the Alafia River did not experience reduced precipitation. Flows remained near normal during most of the 21 month period with the lowest flow, 79 cfs, occurring in May 1967 and the lowest percentage of expected flow, 64.4 percent on an actual flow of 89 cfs, occurring in April, 1968. Flow from Lithia Springs was measured periodically, and the discharge values were interpolated from a plot of the individual measurements.

Palm River (Sixmile Creek) is a small tributary lying between the Alafia and Hillsborough River basins. It has a total drainage area of 40 square miles, of which 28 square miles are tributary above the gage at State Road 574. Only four years of record were available for calculating expected mean monthly flow; therefore, an arithmetic mean was used instead of a probability distribution. Measurements were adjusted for increased drainage, but there are no constant sources (springs, etc.) below the gage (Appendix Table A.4).

Appendix Table A.5 summarizes the expected and actual flows as measured at the gaging stations and the estimated total freshwater inflow to the Bay from all tributaries. Figure 6.5 presents a graphic comparison of actual and expected flows at the gaging stations.


N
0 1/2 1 1 1/2 2
Statute Miles
McKAY BAY
Hookers Point
Ballast Point
INTERBAY PENINSULA
Long Island
MacDILL AIR FORCE BASE
Gadsden Point

NOTE: LENGTH OF ARROW IS NOT PROPORTIONAL TO VELOCITY

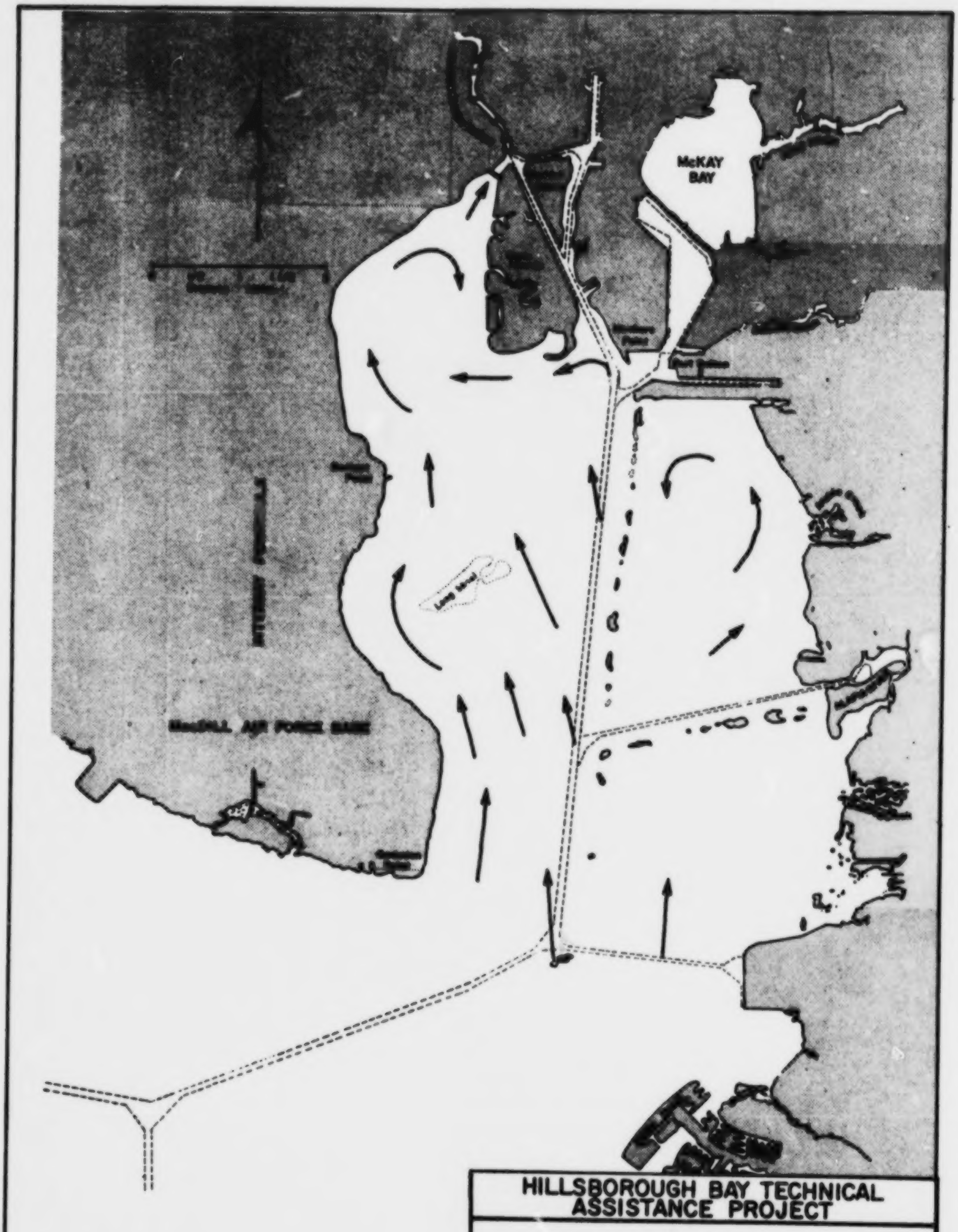
HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

GENERAL EBB CURRENT PATTERN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

FIGURE 6.1

11a


McKAY BAY
Long Island
MacDILL AIR FORCE BASE

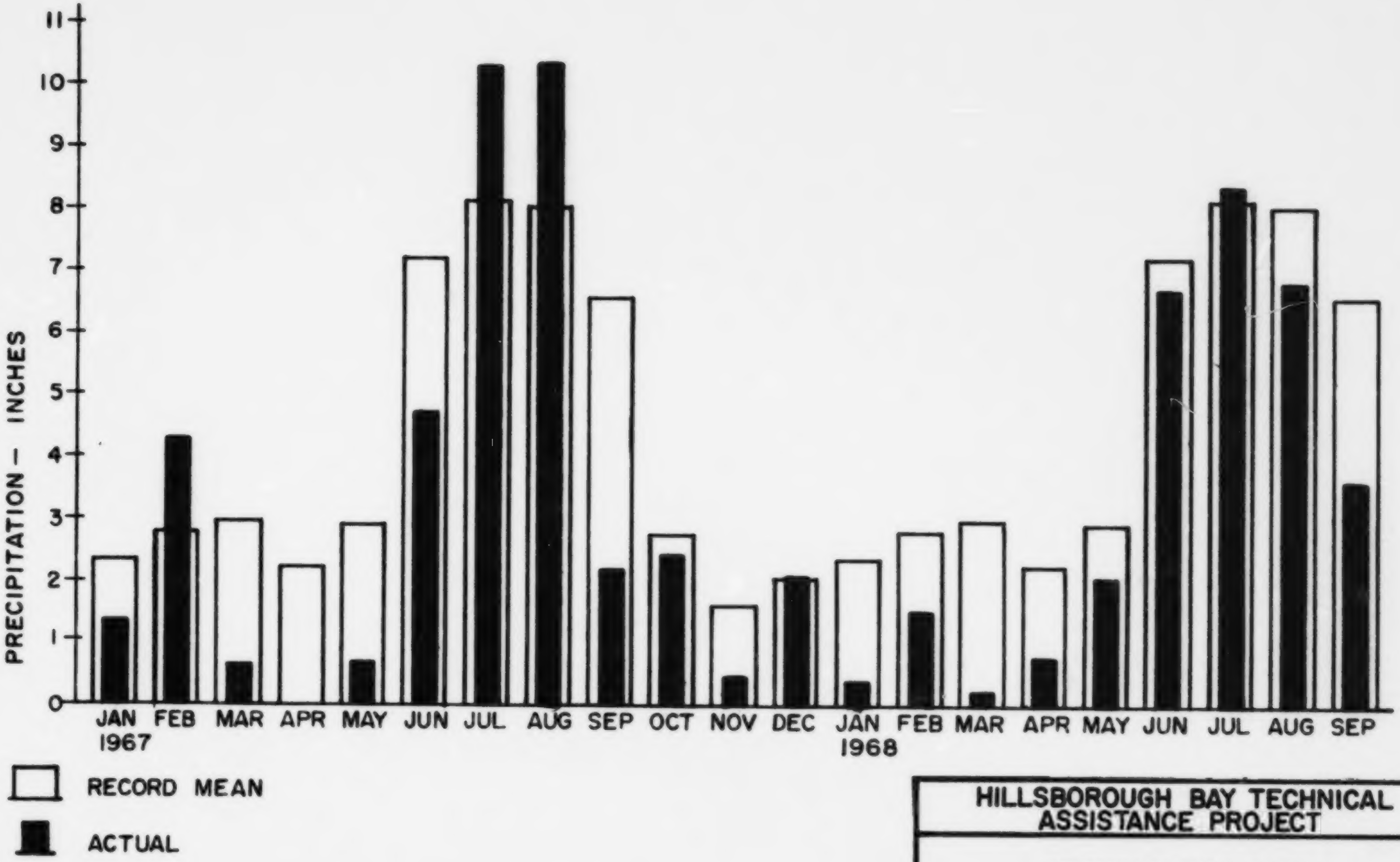
NOTE: LENGTH OF ARROW IS NOT PROPORTIONAL TO VELOCITY

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

GENERAL FLOOD CURRENT PATTERN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

FIGURE 6.2



HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

PRECIPITATION DATA

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

FIGURE 6.3

11-C

JANUARY
7440 Obs.

B **PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:**

DIRECTION	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	AV. SPEED
N	1	4	4	2	*					11	8.7
NNE	1	3	3	2	*					8	9.0
NE	1	3	2	1	*					7	8.0
ENE	*	3	3	1	*					8	8.1
E	1	4	3	1	*					8	7.4
ESE	*	2	2	*	*					4	8.2
SE	*	1	2	1						4	8.7
SSE	*	1	2	1	*	*				5	9.7
S	*	2	3	2	*	*				8	10.2
SSW	*	1	2	1	*					5	9.8
SW	*	1	1	*	*	*				3	7.6
WSW	*	1	2	*	*	*				4	8.4
W	*	1	2	*	*	*				4	9.4
WNW	*	2	2	1	1	*	*			6	11.5
NW	*	2	2	2	*	*				7	11.2
NNW	*	2	2	2	*	*				7	10.4
CALM	3									3	
TOTAL	10	33	36	17	3	1	*			100	8.9

FEBRUARY
6792 Obs.

B **PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:**

DIRECTION	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	AV. SPEED
N	1	3	4	1	*					9	8.9
NNE	*	2	2	1	*					6	8.5
NE	1	3	3	1	*					7	8.3
ENE	*	2	3	1	*	*				7	8.9
E	*	3	4	2	*	*				9	9.2
ESE	*	2	3	1	*	*				6	9.5
SE	*	1	2	1	*					5	9.4
SSE	*	1	2	1	*	*				5	10.5
S	*	2	4	3	1	*				10	11.7
SSW	*	1	2	1	*	*				5	11.3
SW	*	1	2	1	*					4	9.3
WSW	*	1	2	1	*	*				4	9.9
W	*	1	1	1	*	*	*			4	11.2
WNW	*	1	1	1	1	*	*			5	13.2
NW	*	2	2	2	1	*	*			6	12.0
NNW	*	2	2	1	*	*				5	10.0
CALM	3									3	
TOTAL	7	28	39	21	4	1	*			100	9.8

MARCH
7440 Obs.

B **PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:**

DIRECTION	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	AV. SPEED
N	1	3	3	2	*					8	9.1
NNE	*	2	2	1	*	*				6	9.0
NE	*	2	2	1	*	*				5	8.6
ENE	*	2	2	1	*	*				6	9.6
E	1	3	3	1	*	*				7	8.3
ESE	*	2	2	1	*	*				5	9.2
SE	*	2	2	1	*	*				5	9.1
SSE	*	1	2	1	*	*				6	10.3
S	*	1	4	3	1	*				9	11.6
SSW	*	1	2	2	1	*				6	12.4
SW	*	1	2	1	*	*				5	9.5
WSW	*	1	3	1	*					5	10.0
W	*	1	3	1	*	*				5	10.2
WNW	*	2	2	2	1	*	*			7	11.9
NW	*	1	2	1	*	*	*			5	10.9
NNW	*	2	1	1	*	*				4	9.7
CALM	3									3	
TOTAL	8	27	39	21	4	1	*			100	9.7

APRIL
7200 Obs.

B **PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:**

DIRECTION	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	AV. SPEED
N	1	2	2	1	*	*				6	9.1
NNE	*	1	2	*		*				4	8.0
NE	1	2	3	1	*	*				7	7.9
ENE	*	3	4	2	*	*				10	9.2
E	*	4	5	2	*	*				11	9.6
ESE	*	2	4	2	*					8	9.9
SE	*	1	3	1	*					5	9.9
SSE	*	1	2	2	*	*				5	10.4
S	*	1	2	2	1	*				6	11.9
SSW	*	1	2	2	*	*				5	11.9
SW	*	1	2	1	*					4	9.4
WSW	*	1	3	1	*	*				5	10.2
W	*	2	3	2	1	*				7	11.3
WNW	*	1	3	2	1	*				7	11.4
NW	*	1	2	1	*	*				5	10.2
NNW	*	1	2	1	*	*				4	10.6
CALM	2									2	
TOTAL	7	26	42	21	4	1				100	9.8

MAY
7440 Obs.

B **PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:**

DIRECTION	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	AV. SPEED
N	1	3	2	1	*					6	7.6
NNE	1	2	2	1						5	8.6
NE	1	2	2	1	*					6	8.5
ENE	*	3	4	2	1	*				9	10.3
E	1	4	5	2	*	*				11	9.2
ESE	*	2	4	1	*					8	9.2
SE	*	2	3	1	*					5	8.9
SSE	*	1	2	1	*					4	9.3
S	*	2	2	1	*	*				5	9.2
SSW	*	1	1	1	*					3	10.5
SW	*	1	2	1	*					5	10.0
WSW	*	1	3	2	*					6	10.9
W	*	1	3	3	*	*				8	11.2
WNW	*	2	2	2	*					6	10.2
NW	*	2	2	1	*	*				5	8.8
NNW	*	1	1	*	*	*				4	8.2
CALM	4									4	
TOTAL	10	27	41	20	2	*				100	9.1

JUNE
7200 Obs.

B **PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:**

DIRECTION	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	AV. SPEED
N	1	2	1	*	*					4	7.5
NNE	*	1	1	1	*					4	8.5
NE	1	2	2	1	*	*				5	8.2
ENE	1	3	3	1	*	*				8	8.6
E	1	4	3	1	*	*				10	8.0
ESE	1	3	3	1	*					7	8.1
SE	1	3	2	1	*					6	7.9
SSE	*	2	2	1	*					5	8.5
S	*	2	2	1	*	*	*			5	8.7
SSW	*	1	2	1	*					5	9.4
SW	*	2	4	1	*					6	9.7
WSW	*	1	5	3	*					9	10.5
W	*	2	5	3	*					10	10.0
WNW	*	2	2	1	*	*				5	9.5
NW	*	1	1	*	*	*				3	8.2
NNW	*	1	1	*	*					3	8.3
CALM	5									5	
TOTAL	12	32	39	16	2	*	*			100	8.5

SUMMARY OF HOURLY OBSERVATIONS 1951 – 1960
INTERNATIONAL AIRPORT, TAMPA, FLORIDA
WEATHER BUREAU, U.S. DEPARTMENT OF COMMERCE

HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

WIND DIRECTION AND SPEED

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

FIGURE 6.4

11-d

JULY
7440 Obs.

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR)										AVG. SPEED
	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	
N	1	2	1	+	+					4	6.9
NNE	+	1	1	+	+					3	6.9
NE	1	3	1	+	+					5	6.2
ENE	1	4	2	+						7	6.9
E	2	7	4	1	+					14	6.9
ESE	1	5	3	1	+					9	7.3
SE	1	4	2	+	+	+				8	7.2
SSE	+	3	3	1	+	+				7	7.9
S	1	2	3	1	+	+	+			6	8.4
SSW	+	1	2	1	+	+				4	9.3
SW	+	2	3	1						5	8.5
WSW	+	2	4	1						7	9.2
W	+	2	4	1		+				7	9.3
WNW	+	1	1	+	+					3	8.6
NW	+	1	1	+						3	7.1
NNW	+	1	1	+	+					2	7.7
CALM	5									5	
TOTAL	16	41	37	8	+	+	+			100	7.4

AUGUST
7440 Obs.

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR)										AVG. SPEED
	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	
N	1	2	2	+	+	+				5	7.3
NNE	1	2	2	+	+					5	7.4
NE	1	3	2	+						7	7.1
ENE	1	4	3	1	+	+				9	7.7
E	2	5	3	+	+					11	6.4
ESE	1	4	2	+	+					7	6.9
SE	1	2	2	+	+	+				5	7.2
SSE	+	2	1	+		+				4	7.5
S	+	2	2	+		+				4	7.4
SSW	+	1	2	+						4	8.2
SW	+	2	3	+						6	8.1
WSW	+	2	4	1		+				6	8.9
W	1	2	4	1	+					9	9.0
WNW	+	2	2	1	+					5	8.6
NW	+	2	1	+	+					4	7.6
NNW	+	2	1	+						3	7.2
CALM	6									6	
TOTAL	16	39	37	7	+	+				100	7.2

SEPTEMBER
7200 Obs.

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR)										AVG. SPEED
	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	
N	+	3	2	1	+			+	+	6	8.1
NNE	+	4	4	1	+	+	+	+		10	9.2
NE	1	5	6	1	+	+				13	8.5
ENE	1	6	7	2	+	+				15	8.9
E	1	6	5	2	+	+				14	8.3
ESE	+	3	3	1	+					8	8.4
SE	+	2	2	+	+	+				6	8.1
SSE	+	2	2	1	+					5	8.3
S	+	2	1	1	+	+	+			4	9.0
SSW	+	1	1	+	+					2	9.7
SW	+	1	1	+	+					3	8.2
WSW	+	1	1	+	+					3	9.2
W	+	1	2	+	+	+	+			3	9.6
WNW	+	1	1	+	+		+		+	2	9.4
NW	+	1	1	+					+	2	8.6
NNW	+	1	1	+					+	2	7.9
CALM	3									3	
TOTAL	8	37	41	12	2	+	+	+	+	100	8.4

OCTOBER
7440 Obs.

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR)										AVG. SPEED
	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	
N	1	5	6	2	+	+	+	+		15	8.8
NNE	+	4	9	3	+	+	+	+		17	10.0
NE	1	4	7	2	+	+				14	9.1
ENE	+	3	5	3	+	+		+		12	10.0
E	1	3	4	1	+		+			9	8.9
ESE	+	2	2	+	+					4	8.4
SE	+	1	1	+	+					3	8.4
SSE	+	1	1	+						3	8.7
S	+	1	1	+	+					2	8.5
SSW	+	+	1	+						1	8.8
SW	+	1	1	+	+					2	8.3
WSW	+	1	1	+						2	8.5
W	+	1	1	+	+					2	8.4
WNW	+	1	1	+	+	+				3	9.1
NW	+	1	1	1	+	+				4	9.0
NNW	+	2	2	1	+					5	9.1
CALM	3									3	
TOTAL	8	30	45	16	1	+	+	+		100	8.9

NOVEMBER
7200 Obs.

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR)										AVG. SPEED
	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	
N	1	5	6	2	+					14	9.0
NNE	+	4	7	4	+					15	9.9
NE	+	3	7	2	+					12	9.3
ENE	+	3	5	2	+	+				10	9.3
E	+	2	3	1	+					7	8.9
ESE	+	1	2	1	+					5	9.3
SE	+	1	2	+	+					4	8.7
SSE	+	1	2	1		+				4	9.2
S	+	1	3	1	+					5	9.4
SSW	+	1	1	1	+					3	9.5
SW	+	1	1	+	+					2	7.7
WSW	+	1	1	+						2	7.9
W	+	1	1	+		+				2	8.2
WNW	+	1	1	+	+	+				3	9.8
NW	+	1	2	1	+	+				4	10.2
NNW	+	2	2	1	+	+				6	10.1
CALM	2									2	
TOTAL	6	29	47	17	2	+				100	9.1

DECEMBER
7440 Obs.

B PERCENTAGE FREQUENCIES OF WIND DIRECTION AND SPEED:

DIRECTION	HOURLY OBSERVATIONS OF WIND SPEED (IN MILES PER HOUR)										AVG. SPEED
	0 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	39 - 46	47 & OVER	TOTAL	
N	+	6	6	3	+	+				16	9.9
NNE	+	2	5	3	+	+				11	10.4
NE	+	3	4	2	+					9	9.0
ENE	+	3	5	2	+					11	9.2
E	1	3	3	1	+					9	8.4
ESE	+	2	3	1						5	8.7
SE	+	2	2	1	+					4	8.3
SSE	+	1	2	1	+	+				4	9.4
S	+	1	2	2	+	+				6	10.4
SSW	+	1	2	1	+					4	9.7
SW	+	1	1	+						2	8.0
WSW	+	1	1	+	+					2	8.1
W	+	1	1	+	+					2	8.6
WNW	+	1	1	1	+	+	+			3	11.7
NW	+	1	2	1	1	+				5	11.6
NNW	+	2	2	2	+	+				6	10.4
CALM	3									3	
TOTAL	7	29	42	19	3	+	+			100	9.4

SUMMARY OF HOURLY OBSERVATIONS 1951-1960
INTERNATIONAL AIRPORT, TAMPA, FLORIDA
WEATHER BUREAU, U.S. DEPARTMENT OF COMMERCE

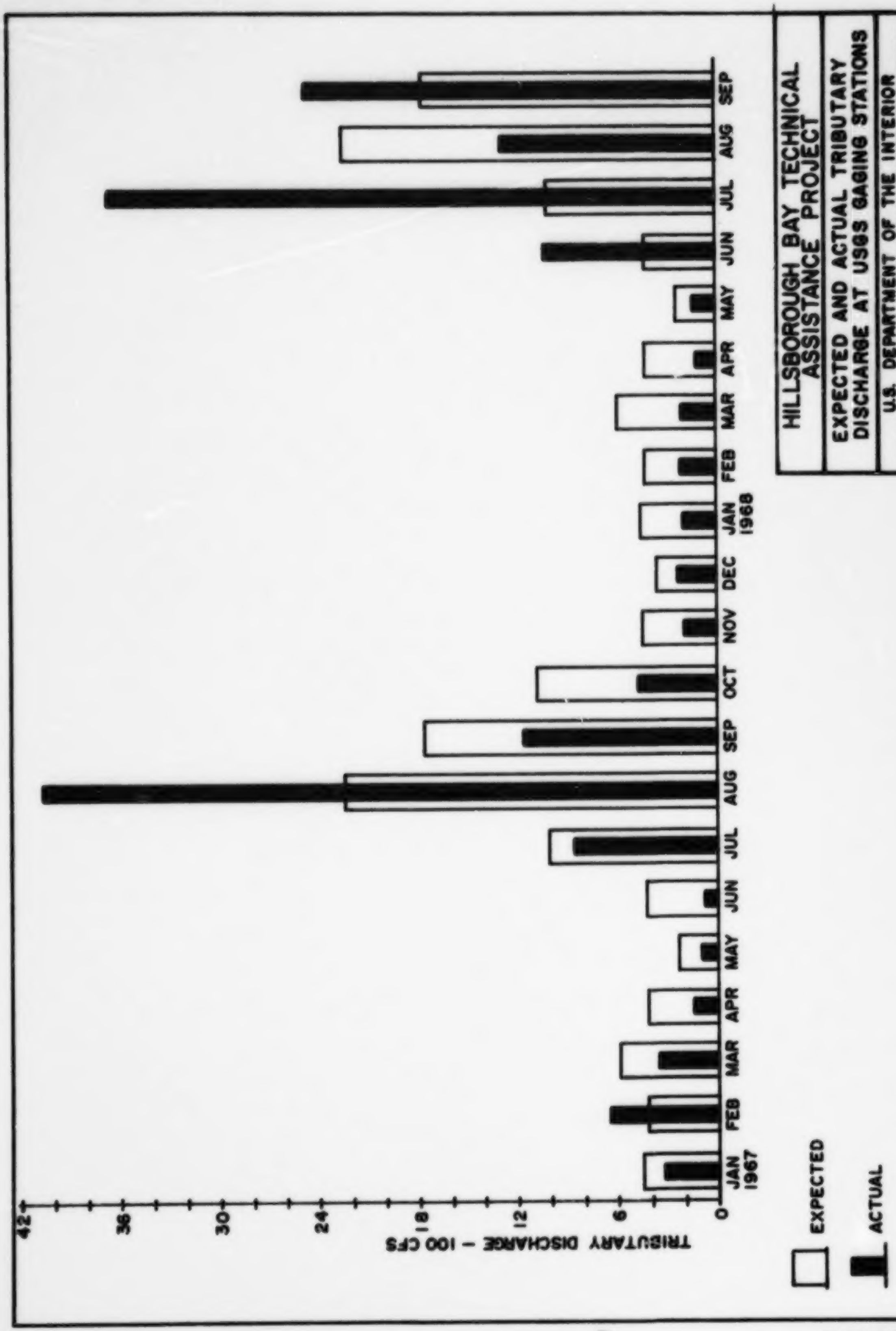
HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

WIND DIRECTION AND SPEED

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

11-E

FIGURE 6.4 (Continued)



HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

EXPECTED AND ACTUAL TRIBUTARY DISCHARGE AT USGS GAGING STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

11-F

FIGURE 6.5

Hillsborough Bay Technical
Assistance Project

Table 6.1

EXPECTED FRESH WATER DISCHARGES - HILLSBOROUGH BAY

Month	Hillsborough River[1]			Alafia River[2]			Sixmile Cr. (Palm R.)	Total Inflow		
	Mean	% Equal to or Less		Mean	% Equal to or Less		Mean[3]	Mean	% Equal to or Less	
		10%	90%		10%	90%			10%	90%
Jan.	240	74	750	170	62	480	44	460	190	1260
Feb.	240	76	750	185	59	600	44	430	190	1050
March	260	62	1800	190	47	750	105	600	230	3000
April	160	60	1450	138	35	550	68	430	165	2100
May	110	39	310	74	21	260	50	245	125	490
June	175	38	800	210	47	950	58	430	135	1550
July	510	112	2350	450	165	1450	96	1200	330	4350
Aug.	1050	305	2700	590	230	1500	150	2250	580	4100
Sept.	1200	260	5600	600	185	1950	115	1770	720	8000
Oct.	610	150	2450	315	105	940	56	1080	330	2900
Nov.	240	98	580	150	86	355	34	460	215	940
Dec.	155	91	385	140	85	295	34	365	200	670

1. Based on 28 years of record (1932 - 1960) at Tampa Water Supply Dam.
2. Based on 22 years of record (1938 - 1960) at Lithia Gage.
3. Based on 4 years of record (1956 - 1960) at S. R. 574 Gage.

7.

WATER USE

In estuaries, the principal water uses are commerce, industrial cooling water, fishing, recreation and shellfish production. Estuaries are a vital link in the life cycle of many valuable marine and estuarine species and the public expects bodies of water to be aesthetically enjoyable, attractive, and refreshing. Pollution causes damages to valuable shellfish and commercial fishing industry; increased maintenance costs for commercial and recreational boats; closing of bathing beaches; restriction of shoreline development; and widespread aesthetic nuisances.

Commerce and Industrial Uses

Improvement of the Port of Tampa began with the passage of the Rivers and Harbors Act in 1888 and has progressed steadily to the present. The present value and future prospects for Port of Tampa has been previously discussed under "Economics." Approximately 1.5 billion gallons per day of Hillsborough Bay water are used for industrial cooling, principally by thermal electric generating stations. Expanded port facilities and industrial development will continue to have a major effect on water use in Hillsborough Bay, particularly in the northeastern section.

Recreational Boating

A survey was made of 11 marinas located on Tampa and Hillsborough Bay. Of a total of 679 boats stored in the 11 marinas, only 174 (25.6 percent) were located on Hillsborough Bay. It is estimated that these commercial storage facilities account for 75 percent of the larger inboard yachts, the remaining 25 percent being stored in private docking facilities. This predominant preference for Old Tampa Bay reflects the desire of the boat owner for cleaner water and attendant lower upkeep and maintenance costs. Based on average estimated cost and recommended maintenance frequencies supplied by marina operators, the additional cost of mooring a 35 foot yacht or sailboat in Hillsborough Bay as compared to Old Tampa Bay is $220 per year.

Swimming

Hillsborough Bay is not presently suitable for body contact recreation even though there are two beaches. One beach, located in a seaplane basin at the southern tip of Davis Islands, remains popular even though the water does not meet State Board of Health bacteriological requirements (1000 total coliform/100 ml). The Hillsborough County Health Department has erected warning signs along this beach several times, but each time they were destroyed by vandals. Therefore, the practice of erecting warning signs has been suspended. The other beach and picnic area is located at Gadsden Point on MacDill Air Force Base and is closed to swimming because of poor water quality. However, several surf fishermen have been observed wading chest deep in the immediate area. Also, on the Alafia River at the U.S. Highway 41 bridge, there is a county park where small boats may be launched and children are often seen swimming even though the water does not meet State Board of Health Standards. Thus, as a result of poor water quality, the potential benefit of body contact recreation has been foregone.

Fish

The Bureau of Commercial Fisheries Biological Station at St. Petersburg Beach reports that a total of 57 families, including 116 genera and 147 species of fish have been collected from Tampa Bay. Of that total, there were 19 principal species. "The importance of the Tampa Bay area as a nursery for commercially important animals is shown by the presence in the Bay of the young of 19 species of fish, crab and shrimp. Eighteen species were caught in the lower Bay, 13 in the central Bay, and 15 in both Old Tampa Bay and Hillsborough Bay. The highest catch per unit of effort for these species occurred in Old Tampa Bay and the lowest in Hillsborough Bay."(7)

The above statements indicate that fewer numbers of species and fewer numbers of individuals of these species were found in Hillsborough Bay than in other sections of the Tampa Bay complex. This is further supported by the observation that sport fishermen are very much in evidence around Old Tampa Bay, fishing from both boats and bridges, while very few fishermen are to be found on Hillsborough Bay.

Shellfish

Past and Present Uses and Restrictions:

In the late 1800's, commercial oyster production amounted to approximately 300,000 pounds of oyster meat per year harvested from Hillsborough Bay. The present dockside value of this harvest would be $100,000.00. Economic studies indicate that the dockside value represents only about 20 to 25 percent of the total value of shellfish industries. There is at present no shellfish industry in Hillsborough Bay.(8) Thus, a direct damage of approximately one-half million dollars per year is resulting from loss of shellfish due to siltation and pollution. The Bureau of Commercial Fisheries estimates that if Hillsborough Bay were free from pollution and resulting bottom deposits, about 5,000 acres could be returned to productive oyster culture.

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(7) Personal Communication.

Aesthetics

The aesthetic enjoyment of the Bay through the medium of waterfront property has led to the development of one of Tampa's most desirable residential areas along Bayshore Boulevard and the west side of Davis Islands. Turbid water, bacterial contamination and obnoxious odors have made the Bay an aesthetic liability and have reduced the benefits which waterfront residency should afford and for which the residents have invested substantial sums of money. In addition, the revolting sights and obnoxious odors arising from the Bay adjacent to Bayshore Boulevard offend resident and visitor alike and tend to negate the enjoyment of an otherwise attractive parkway.

More and more, the shoreline must be considered an extension of the front lawn or park of the abutting property. Maintenance of the waterfront must be considered of equal importance to the maintenance of adjacent land if the full value of either is to be assured.

Applicability of State Standards

Classification and water quality standards submitted by the State of Florida in compliance with the Water Pollution Act 84-660 as amended by the Clean Waters Restoration Act of 1966 (PL 89-753) provided water quality criteria for five classes of water usage. Hillsborough Bay in its entirety is recommended for Class IV. Appropriate sections of the Florida Water Quality Standards are contained in Table 7.1.

CAUTION
POLLUTED WATER
AVOID ALL CONTACT
MacDILL AFB
MILITARY PUBLIC HEALTH SERVICE

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(8) Loc. Cit.

Table 7.1

APPLICABLE FLORIDA STATE WATER QUALITY STANDARDS

A. 28-5.10 Criteria: Class IV waters – agricultural and industrial water supply –

The following criteria are for classification of waters to be used for agricultural or stock watering, or industrial water supply.

"(1) Sewage, industrial wastes or other wastes – none which are not effectively treated or controlled to the satisfaction of the regulatory agency.

(2) pH – not more than one (1.0) unit from the normal or not less than six (6.0) nor greater than 8.5.

(3) Temperature – shall not be increased so as to cause any damage or harm to the aquatic life or vegetation of the receiving waters or interfere with any beneficial use assigned to such waters.

(4) Dissolved oxygen – shall not be depressed below the values of four (4.0) ppm (unless background information available to the regulatory agency indicates prior existence under unpolluted conditions of lower values). In such cases, lower limits may be utilized after approval by the regulatory authority.

(5) Color, odor and taste producing substances and other deleterious substances, including other chemical compounds, attributable to domestic wastes, industrial wastes and other wastes – only such amounts as will not render the waters unsuitable for agricultural irrigation, livestock watering, industrial cooling, industrial process water supply purposes and fish survival.

(6) Turbidity – shall not exceed fifty (50) Jackson units as related to standard candle turbidimeter above background."

B. 28-5.09 Criteria: Class III waters – recreation – propagation and management of fish and wildlife.

The following criteria are for classification of waters to be used for recreational purposes, including such body contact activities as swimming and water skiing; and for the maintenance of a well-balanced fish and wildlife population. All coastal and beach waters, including off-shore waters, not otherwise classified shall be classified as Class III; however waters of the open ocean shall be maintained at a dissolved oxygen of not less than 5.0 ppm, and any streams specifically listed in Section 28-5.21 by a separate listing designated as "Special Stream Classification" shall similarly be maintained at a minimum dissolved oxygen of five (5.0) ppm.

"(1) Sewage, industrial wastes, or other wastes – any industrial waste or other wastes shall be effectively treated by the latest modern technological advances as approved by the regulatory agency.

(2) Dissolved Oxygen – shall not be artificially depressed below the values four (4.0) ppm (unless background information available to the regulatory agency indicates prior existence under unpolluted conditions of lower values). In such cases, lower limits may be utilized after approval by the regulatory authority.

(3) Bacteriological – coliform group not to exceed 1,000 per 100 as a monthly average, (either MPN or MF counts); nor to exceed this number in more than 20% of the samples examined during any month; nor exceed 2,400 per 100 ml (MPN or MF count) on any day. This criteria shall apply only to waters used for body contact activities.

(4) Toxic substances – free from substances attributable to municipal, industrial, agricultural or other discharges in concentrations or combinations which are toxic or harmful to humans, animal or aquatic life.

(5) Deleterious – free from materials attributable to municipal, industrial, agricultural, or other discharges producing color, odor or other conditions in such degree as to create a nuisance."

8.

POLLUTION SOURCES

Hillsborough Bay and its tributary streams receive the waste of the Greater Tampa area. Surrounded by the city and adjacent suburban and industrial areas, the Bay has, over the years, developed as an ultimate disposal place for raw wastes from home and industry, effluents from waste treatment plants, hyacinths from tributary streams, oil from the tanks and bilges of ships, miscellaneous trash and debris from thoughtless or uninformed persons, product losses from terminal facilities, and storm waters from the city of Tampa. There are many individual waste sources, most of which have only minor effect on the water quality of the Bay. These dispersed sources were relatively easy to identify and observe, but difficult to quantify. Some 48 industrial plants and 20 municipal waste treatments plants were inventoried during the waste source survey. A detailed presentation of these sources is contained in the Technical Appendix. Of these 68 waste sources, only four were considered key sources of municipal or industrial waste affecting the water quality of Hillsborough Bay: MacDill Air Force Base sewage treatment plant, Nitram Chemical Company, Tampa sewage treatment plant, and U.S. Phosphoric Products. In addition, three tributary streams, the Alafia River, the Hillsborough River, and the Palm River (Sixmile Creek), were considered as point sources in their effect on Hillsborough Bay. It is the purpose of this section to discuss these seven key waste inputs (see Appendix Table A.6).

Municipal Wastes

The two principal sources of municipal wastes which discharge directly into Hillsborough Bay were the city of Tampa sewage treatment plant on Hookers Point and MacDill Air Force Base sewage treatment plant located about one-half mile north of Gadsden Point on the eastern side of the airbase. The city of Tampa sewage treatment plant went into operation in December 1951. It is a well operated primary plant having received many awards from the State Board of Health. It has the following specific design features: aerated grit chambers, separate covered heated sludge digestors, and pre and post chlorination, in addition to primary settling design for two-hour detention time. The plant design capacity is 36 million gallons per day (MGD) with a present flow of approximately 28 MGD. The plant effluent is discharged to Hillsborough Bay through an 84 inch submerged pipe approximately 20 feet below the water surface at the eastern edge of the main ship channel adjacent to the southern end of Davis Islands. Plant records for the period of June 1967 through July 1968 show that the average population served for this period of study was approximately 248,000. The plant also receives the industrial wastes from approximately 130 industries located within the city of Tampa and the immediate adjacent areas. Effluent waste loads based on thirty-four 24-hour composite samples expressed as mass units and percentage of the total waste input into the Bay were:

Flow	27.8 MGD	
5-Day B.O.D.	49,000 lbs/day	85.4%
Ultimate B.O.D.	66,000 lbs/day	84.5%
Total Filterable Residue	25,900 lbs/day	35.4%
Volatile Filterable Residue	17,700 lbs/day	48.7%
Ammonia Nitrogen	6,200 lbs/day	41.7%
Kjeldahl Nitrogen(9)	7,300 lbs/day	43.1%
Total Phosphate	2,700 lbs/day	4.8%
pH	6.9	

Ultimate B.O.D. was based on 5-Day B.O.D. and a deoxygenation rate determined from long-term B.O.D.'s. A maximum density of 56×10^6/100 ml of fecal coliform was observed in the Bay adjacent to the plant outfall, and many tests were run (membrane filter technique) at this station (B10) which had colonies too numerous to count. City personnel collected the 24-hour composites for analysis by the project.

MacDill Air Force Base has a primary sewage plant with the following specific design features: grit chamber, communitor, post chlorination and separate unheated sludge digestion, in addition to the primary settling tanks. The Population of MacDill Air Force Base during the period of June 1967 to July 1968 averaged 11,500. This figure represents an averaged 24-hour population of the Base including military personnel and families, and civilian employees. The treatment plant receives no industrial waste. It is designed for 3.0 MGD and has a present flow of approximately 0.7 MGD. The effluent is discharged through a submerged pipeline approximately 200 yards from shore in about four feet of water. The following effluent waste loads, based on thirty-six

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(9) Kjeldahl nitrogen consists of organic nitrogen plus ammonia or the total unsatisfied nitrogen.

13-hour composite samples expressed as mass units and percentage of the total waste input into the Bay, were:

Flow	0.67 MGD	
5-Day B.O.D.	600 lbs/day	1.1%
Ultimate B.O.D.	825 lbs/day	1.1%
Total Filterable Residue	337 lbs/day	0.5%
Volatile Filterable Residue	267 lbs/day	0.8%
Ammonia Nitrogen	130 lbs/day	0.9%
Kjeldahl Nitrogen	136 lbs/day	0.8%
Total Phosphate	53 lbs/day	0.1%
pH	7.1	

Industrial Waste

An industrial waste survey was conducted to determine the sources of industrial waste pollution and their effects on Hillsborough Bay. In cooperation with the Hillsborough County Health Department, a complete and up-to-date inventory of waste sources in Hillsborough Bay tributary area was compiled. Visits were made to 33 industrial plants to interview plant managers or other responsible officials and to establish priorities for a sampling program. Of the industries surveyed, eight were sampled and only two were determined to be significant sources of industrial pollution. Those sources which did not contribute at least 1.0 percent of either organic material (B.O.D.), solids (total or volatile), or nutrients (N and P) were disregarded. The two significant sources were U.S. Phosphoric Products and Nitram Chemical Company.

U.S. Phosphoric Products is located on the north shore of the Alafia River at Gibsonton, Florida. This plant manufactures a wide variety of nitrogen and phosphorus products including: phosphoric acid, normal superphosphate, triple superphosphate, diamonium phosphate, sulfuric acid, ammonia, and sodium fluorosilicate. The wastes from the plant are discharged directly to the lower part of the Alafia River and the east shore of Hillsborough Bay through a series of seven ditches, five of which discharge directly to the Bay. These wastes are characteristically high in soluble phosphate and nitrogen materials and low in pH. The waste loads from this plant expressed as mass units and percentage of the total waste input to the Bay were:

Total Filterable Residue	14,940 lbs/day	20.5%
Ammonia Nitrogen	2,080 lbs/day	14.0%
Kjeldahl Nitrogen	2,080 lbs/day	12.3%
Total Phosphate	8,810 lbs/day	15.8%
Phenolphthalein Acidity	71,600 lbs/day	

Nitram Chemical Company is located on Hartford Street, east of U.S. Highway 41. Nitram produces ammonium nitrate fertilizer in several forms. Sources of liquid waste include: (1) cooling tower blowdown water, (2) quench water used in the manufacture of pelletized ammonium nitrate, and (3) ammonium nitrate barometric condenser water. Liquid wastes are discharged through a lagoon to Delaney Creek and then to Hillsborough Bay. Waste loadings expressed in mass units and as a percentage of the total waste input to the Bay, were:

Ammonia Nitrogen	2,880 lbs/day	19.4%
Total Kjeldahl Nitrogen	2,880 lbs/day	17.0%
pH	8.3	

Tributary Streams

The Alafia River was considered a point source of fresh water flow and pollution. Processes and waste disposal practices of the individual industries and municipalities within the Alafia River basin were outside the scope of this project. However, the results of these practices in terms of the effect on Hillsborough Bay were of major concern. There are 14 phosphate processing plants located in the Alafia River basin. Their combined effect resulted in a discharge of approximately 43,470 pounds per day of total phosphate measured at the Alafia River gaging station at Lithia, Florida. This makes the Alafia River the most significant source of phosphate wastes discharged into Hillsborough Bay. The Alafia River discharged the following pollutional loads expressed in mass units and as a percentage of the total waste input into Hillsborough Bay:

Flow	292 cfs	
5-Day B.O.D.	3,960 lbs/day	6.9%
Total Filterable Residue	16,760 lbs/day	22.9%
Volatile Filterable Residue	8,750 lbs/day	24.1%
Ammonia	3,280 lbs/day	22.1%
Nitrate and Nitrite	3,590 lbs/day	
Total Kjeldahl Nitrogen	3,450 lbs/day	20.4%
Total Phosphate	43,470 lbs/day	78.0%
pH	6.2	

The Hillsborough River, which serves as a municipal water supply for the city of Tampa, received municipal and industrial waste from Plant City and Zephyrhills. Individual waste sources were not measured; however, the Hillsborough River was monitored throughout the project at a point immediately above the water supply reservoir dam. The Hillsborough

River contributed the following pollutional loads, expressed in mass units and as a percentage of the total waste input into the Bay:

Flow	257 cfs	
5-Day B.O.D.	3,300 lbs/day	6.9%
Total Filterable Residue	11,470 lbs/day	15.7%
Volatile Filterable Residue	7,740 lbs/day	21.3%
Ammonia	210 lbs/day	1.4%
Nitrate and Nitrite	40 lbs/day	
Total Kjeldahl Nitrogen	910 lbs/day	5.4%
Total Phosphate	630 lbs/day	1.1%
pH	7.6	

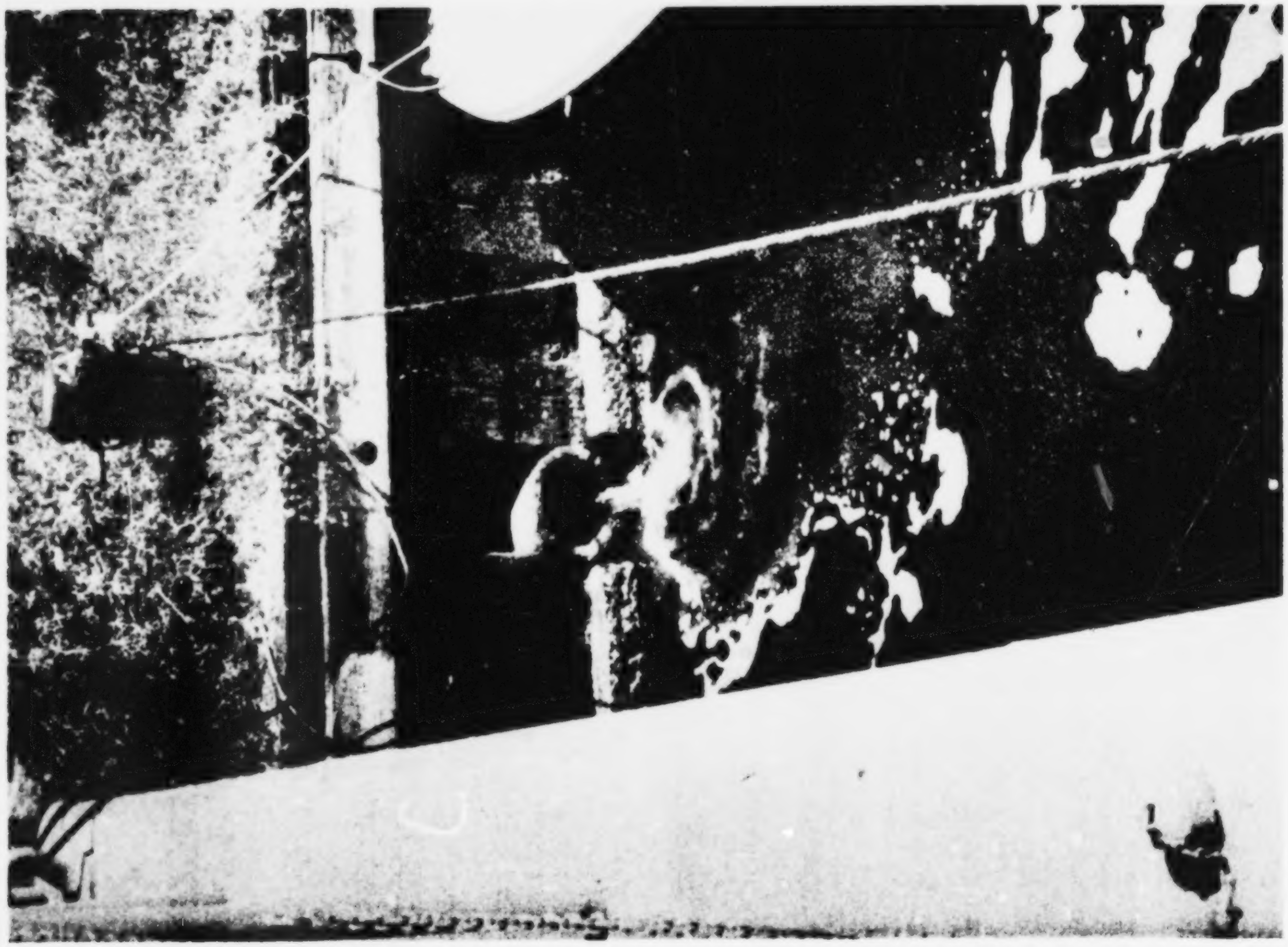
There is one source of wastes on the Hillsborough River which was not included in waste loads mentioned above. The Tampa Water Supply Reservoir located ten miles above the mouth of the river has a severe water hyacinth (*Elchhornia crassipes*) problem. These plants float on the water surface with an unattached root system extending 12 to 18 inches beneath the surface. In the presence of warm temperatures and relatively high nutrient quantities, these plants multiply until they cover the surface of the reservoir. During June and July 1967, the entire surface area of the Hillsborough River reservoir was covered to such an extent that no water could be seen. It is the present practice to treat these hyacinths with a chemical herbicide, 2-4-D, and allow them to sink to the bottom of the reservoir. However, during the summer of 1967, several thousand acres of hyacinths were released from the reservoir to be deposited in Hillsborough Bay. It has been reported by the Florida State Board of Health that hyacinths contribute 200 pounds of nitrogen and 16 pounds of phosphate per acre.[10] During the summer of 1967, an estimated 400,000 pounds of nitrogen and 32,000 pounds of phosphates were released to Hillsborough Bay in this manner. If the practice of flushing these hyacinths from the reservoir should become routine, these hyacinths would become a significant source of nutrient material and would contribute to the deposition of organic bottom sediments in the Bay.

Palm River (Sixmile Creek) is a small tributary of Hillsborough Bay which carries some domestic wastes from septic tanks and industrial wastes from a number of small industries centered in the U.S. 301 – State Road 60 area. Palm River (Sixmile Creek) contributes the following pollutional loads, expressed in mass units and as a percentage of the total waste input, to the Bay:

Flow	43.2 cfs	
5-Day B.O.D.	450 lbs/day	0.8%
Total Filterable Residue	3,570 lbs/day	4.9%
Volatile Filterable Residue	1,850 lbs/day	5.1%
Ammonia	70 lbs/day	0.5%
Nitrate and Nitrite	100 lbs/day	
Total Kjeldahl Nitrogen	180 lbs/day	1.0%
Total Phosphate	100 lbs/day	0.2%
pH	7.7	

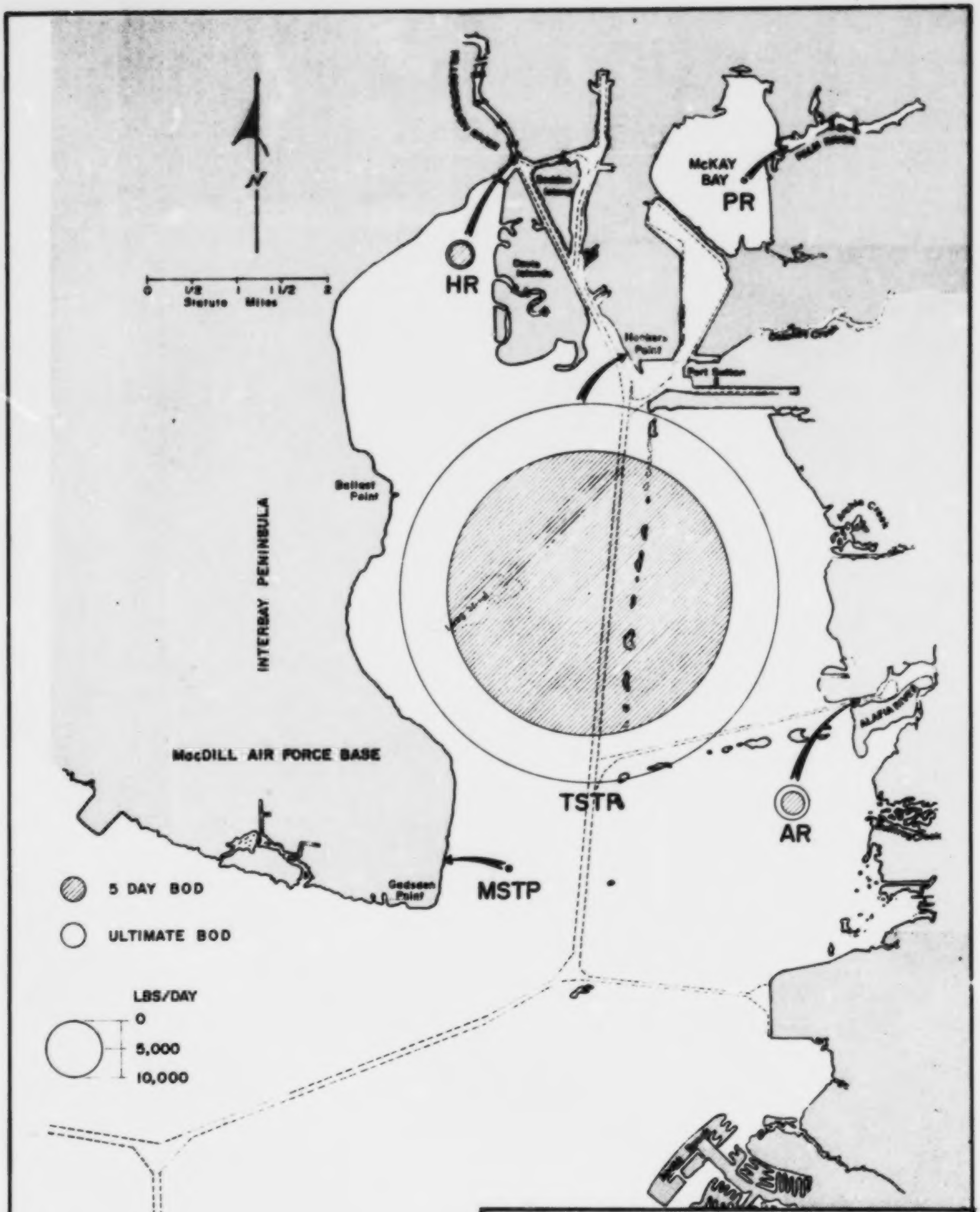
A summary of waste inputs is shown graphically in Figures 8.1 through 8.5. Figure 8.1 shows the relative magnitude of the sources of 5-Day and ultimate B.O.D. The overwhelming source of 5-Day B.O.D. (85.4 percent of the total) was discharged from the Tampa sewage treatment plant with contributions of 6.9 percent and 5.8 percent of the total from the Alafia and Hillsborough Rivers respectively (Figure 8.5). Tampa sewage treatment plant was also the largest contributor of total filterable residue accounting for 35.4 percent of the total input (Figures 8.2 and 8.5). The Alafia River, U.S. Phosphoric Products, Hillsborough River, and Palm River contributed progressively less total filterable residue, 22.9 percent, 20.5 percent, 15.7 percent, and 4.9 percent respectively. The primary source of volatile filterable residue was the Tampa sewage treatment plant (48.7 percent). The Alafia River (24.1 percent), and the Hillsborough River (21.3 percent) contributed progressively less of this material. The total residue from U.S. Phosphoric Products was entirely inorganic. Although the Tampa sewage treatment plant was the largest source of ammonia nitrogen in the Bay (41.7 percent of total input), the combined industrial discharges from the Alafia River, U.S. Phosphoric Products, and Nitram Chemicals amounted to 55.5 percent of the total ammonia discharged (Figures 8.3 and 8.5). Similarly, these three industrially related discharges accounted for 49.7 percent of the total Kjeldahl nitrogen even though the largest single source was the Tampa sewage treatment plant (43 percent). Total phosphates resulted almost exclusively from industrial operations with a combined total of 93.8 percent of the total phosphorus input coming from the Alafia River and U.S. Phosphoric Products (Figures 8.4 and 8.5).

[10] "Biological, Physical and Chemical Study of Lake Apopka, 1962-1964," Florida State Board of Health, March, 1965.



Oil scum is one of the unsightly pollutants of Hillsborough Bay.

14-21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Hookers Point
Port Sutton
Ballast Point
INTERBAY PENINSULA
MacDILL AIR FORCE BASE
TSTP
AR
ALAFIA RIVER
Gadsden Point
MSTP
5 DAY BOD
ULTIMATE BOD
LBS/DAY
0
5,000
10,000

TSTP—TAMPA SEWAGE TREATMENT PLANT
MSTP—MacDILL SEWAGE TREATMENT PLANT
AR—ALAFIA RIVER
HR—HILLSBOROUGH RIVER
PR—PALM RIVER (SIX MILE CREEK)

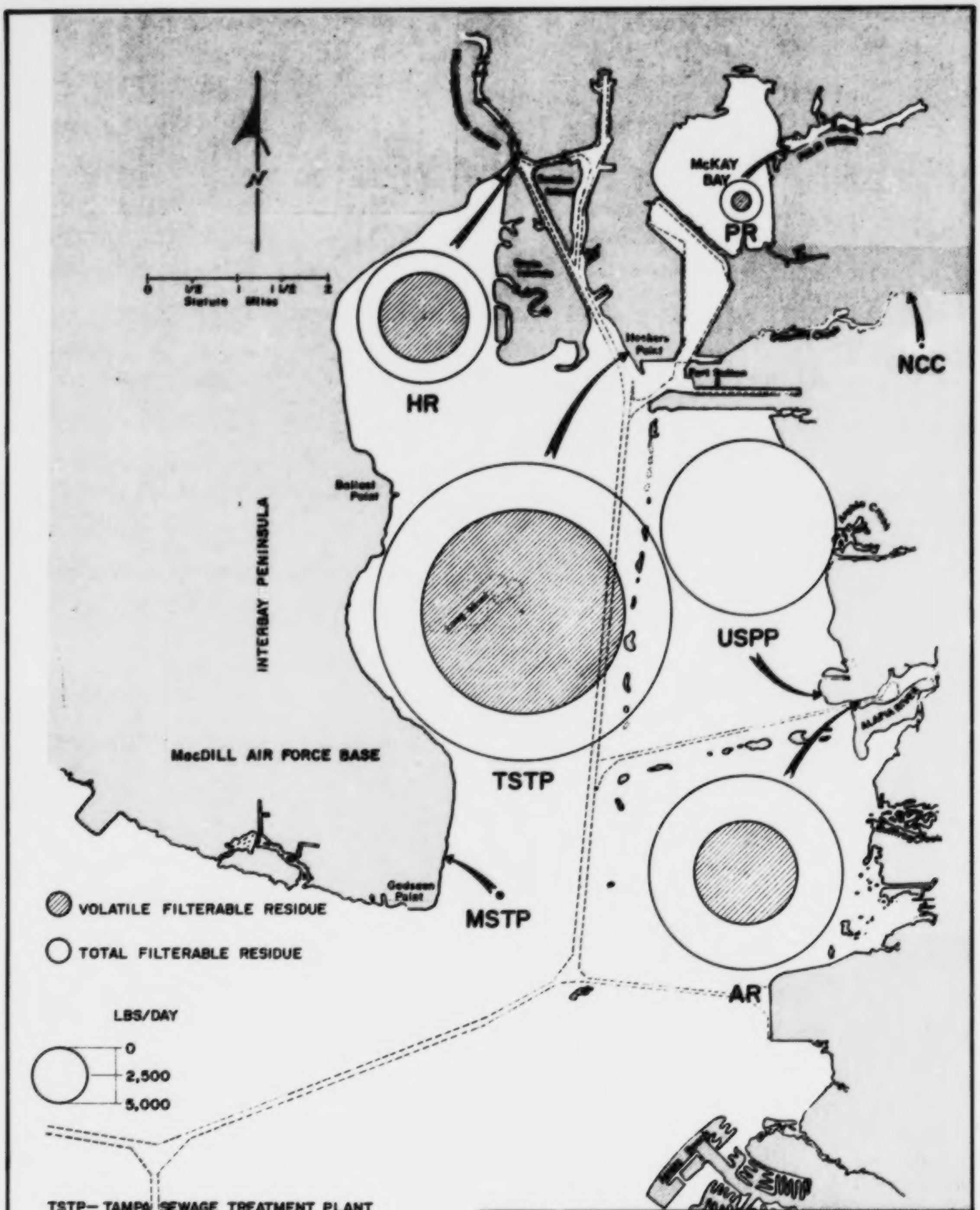
HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

MAJOR WASTE SOURCES
BIOCHEMICAL OXYGEN DEMAND

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeat Water Laboratory Athens, Georgia

19-f

FIGURE 8.1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Hookers Point
HR
Ballast Point
INTERBAY PENINSULA
MacDILL AIR FORCE BASE
TSTP
USPP
AR
Gadsden Point
MSTP
VOLATILE FILTERABLE RESIDUE
TOTAL FILTERABLE RESIDUE
LBS/DAY
0
2,500
5,000

TSTP— TAMPA SEWAGE TREATMENT PLANT
MSTP— MacDILL SEWAGE TREATMENT PLANT
AR—— ALAFIA RIVER
HR—— HILLSBOROUGH RIVER
PR—— PALM RIVER (SIX MILE CREEK)
USPP— U.S. PHOSPHORIC PRODUCTS CO.
NCC— NITRAM CHEMICAL CO.

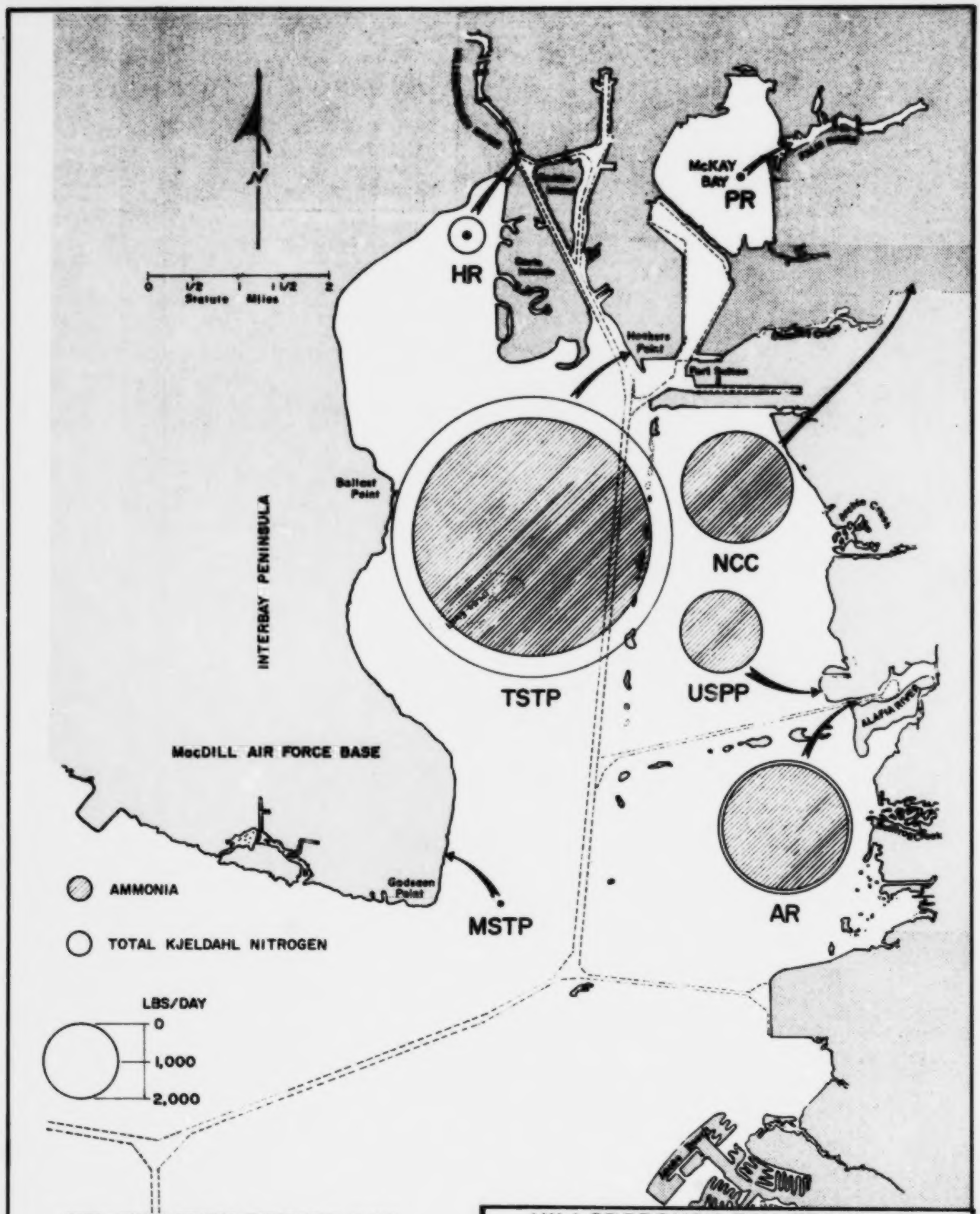
HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

MAJOR WASTE SOURCES
FILTERABLE RESIDUE

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

19-C

FIGURE 8.2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Statute Miles
McKAY BAY
PR
HR
Hookers Point
Port Sutton
Ballast Point
INTERBAY PENINSULA
NCC
TSTP
USPP
ALAFIA RIVER
MacDILL AIR FORCE BASE
Gadsden Point
MSTP
AR
AMMONIA
TOTAL KJELDAHL NITROGEN
LBS/DAY
0
1,000
2,000

TSTP— TAMPA SEWAGE TREATMENT PLANT
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AR—— ALAFIA RIVER
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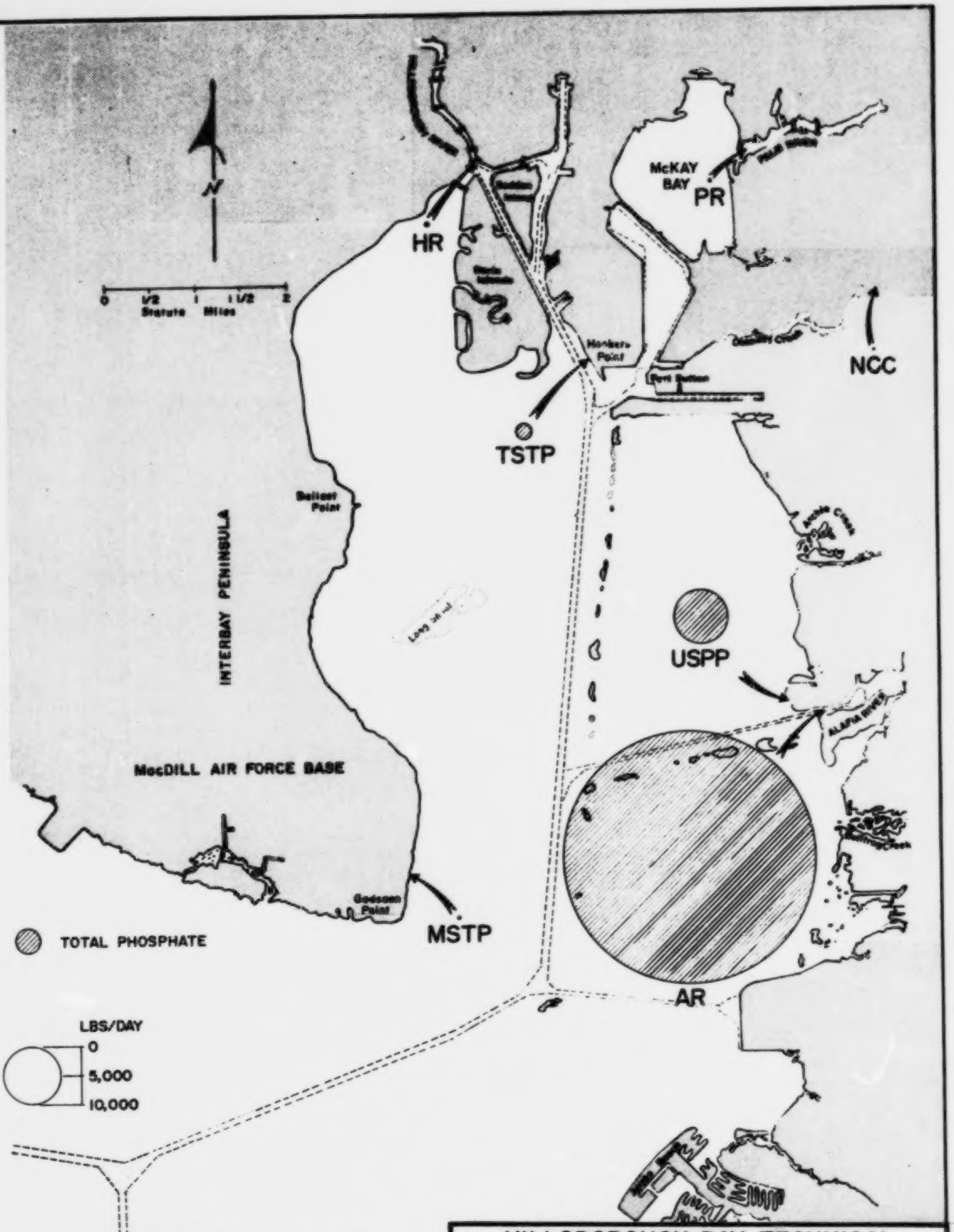
USPP— U.S. PHOSPHORIC PRODUCTS CO.
NCC— NITRAM CHEMICAL CO.

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

MAJOR WASTE SOURCES AMMONIA AND KJELDAHL NITROGEN

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

FIGURE 8.3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Statute Miles
HR
McKAY BAY
PR
NCC
Hookers Point
Port Sutton
TSTP
Ballast Point
INTERBAY PENINSULA
Long Shoal
USPP
Alafia River
MacDILL AIR FORCE BASE
Gadsden Point
MSTP
AR
TOTAL PHOSPHATE
LBS/DAY
0
5,000
10,000

TSTP—TAMPA SEWAGE TREATMENT PLANT
MSTP—MacDILL SEWAGE TREATMENT PLANT
AR——ALAFIA RIVER
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PR——PALM RIVER (SIX MILE CREEK)
USPP—U.S. PHOSPHORIC PRODUCTS CO.
NCC——NITRAM CHEMICAL CO.

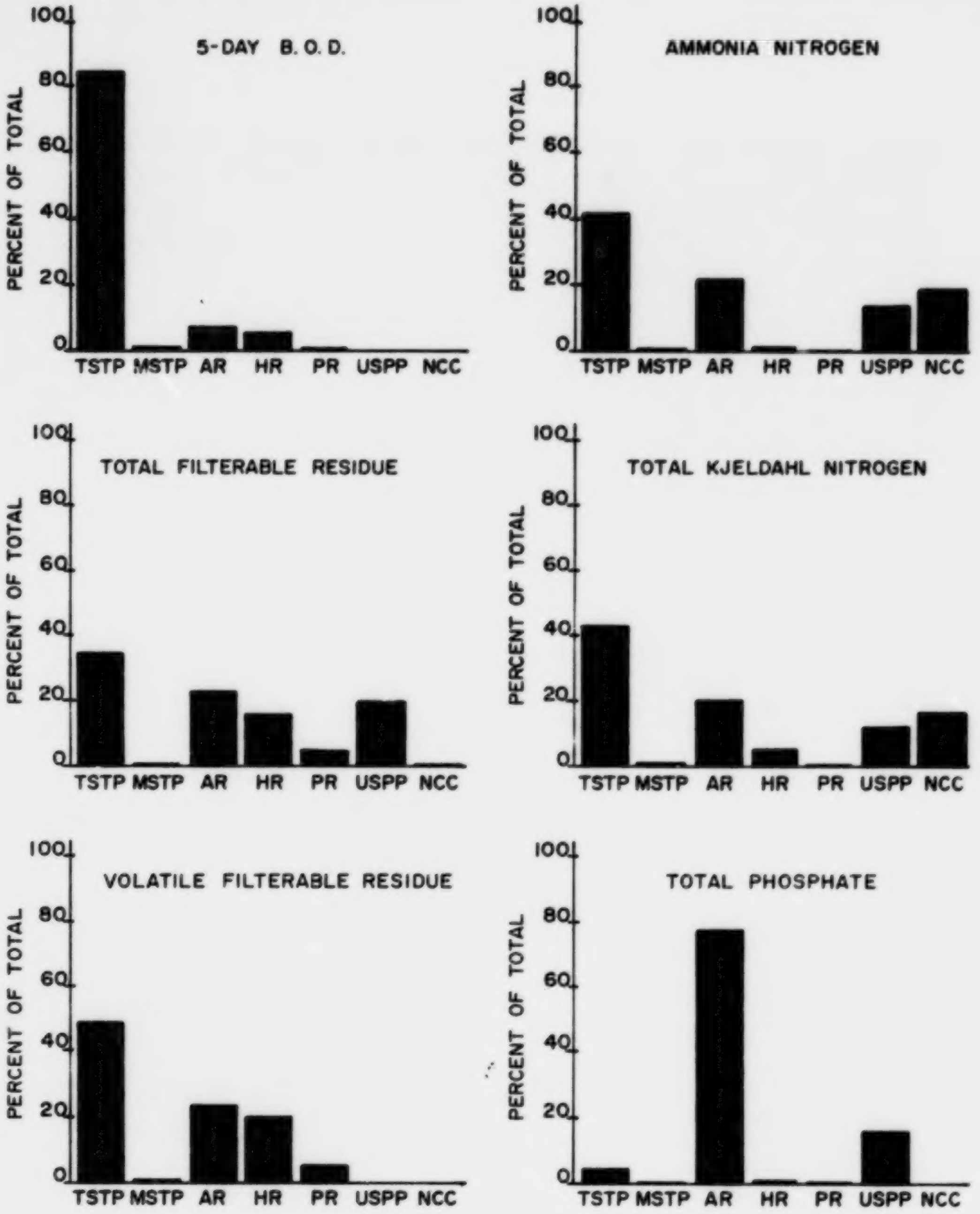
HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

MAJOR WASTE SOURCES
TOTAL PHOSPHATE

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

19-E

FIGURE 8.4



TSTP—TAMPA SEWAGE TREATMENT PLANT
MSTP—MacDILL SEWAGE TREATMENT PLANT
AR——ALAFIA RIVER
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NCC—NITRAM CHEMICAL CO.

HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

MAJOR WASTE SOURCES

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

19-F

FIGURE 8.5

Refuse litters shoreline.

14-68

9.

WATER QUALITY

To measure the effects of waste sources on water quality, and to evaluate the relationship between water quality and odor production, an extensive water quality evaluation was made. The study was subdivided into three general sections: weekly monitoring to measure seasonal variations; short-term intensive studies to evaluate diurnal variations under steady state input conditions; and, special studies to evaluate specific water quality parameters. Laboratory and sampling procedures are summarized in the Appendix (Tables A.7 and A.8). Results of these studies are presented in this section.

Water quality sampling stations were established at 32 locations in the Bay and its tributaries (foldout map at end of report); 19 of these locations were sampled at two depths for a total of 51 sampling points. A description of individual sampling points is listed in the Appendix (Table A.9).

Dissolved Oxygen

Variations in dissolved oxygen are a function of discharge of soluble organic material, oxygen demand and rate of uptake of benthic deposits, photosynthesis and respiration by plankton, water temperature, reaeration and, freshwater input and tidal exchange.

Consideration of monthly average data throughout the survey for five day B.O.D., D.O. and chlorides at various stations throughout the Bay provides insight into the range of observed values and identifies areas of discussion and evaluation of the principal phenomena affecting dissolved oxygen at the particular locations.

Station B-7 is located in the main ship channel between Davis and Seddon Islands and is typical of the heavily utilized harbor area. Dissolved oxygen at the five foot depth was less than 4 mg/l from May through September 1967 with a low value of 1.7 mg/l during August and September. The maximum concentration of about 6.0 to 8.4 mg/l was observed in this area in the late fall and winter season. Dissolved oxygen at the 25 foot depth was below 4 mg/l from April through September and was near zero during August 1967. The maximum value of about 6 mg/l occurred in the late fall and winter season also. The five day B.O.D. was measured from June 1967 to April 1968 at both depths. In general, B.O.D. was slightly higher at the five foot than the 25 foot depth averaging between 1 and 2 mg/l. In July 1967 however, B.O.D. averaged 3.9 mg/l at five feet and 1.9 mg/l at 25 feet. With respect to dissolved oxygen the ship channel between Seddon and Davis Islands is the most severely polluted area in the Bay. During the summer months there is a very distinct stratification between the 5 and 25 foot depths. Values of five day B.O.D. at the 25 foot depth during the summer are lower than at the surface indicating less soluble organic material. However, D.O. is also less at the lower depth which implicates other factors than soluble B.O.D. in causing the added D.O. depletion.

At station B-18 at the confluence of the Alafia River channel and the main ship channel, essentially the same distribution of D.O. and B.O.D. was apparent. This location was considered typical of the open bay area. The minimum monthly average D.O. at the five foot level during the survey period was 4 mg/l in August 1967 with a maximum value of 9.3 mg/l during March 1968. Five day B.O.D. at this point ranged from 1.5 mg/l to 4.8 mg/l with the average for the survey of 3.5 mg/l. At the 25 foot level, the minimum D.O.'s were 1.6 mg/l in December 1967 and 2.2 mg/l in August 1967. The maximum value of 8.1 mg/l occurred in March 1968. However, except for March and April 1968 when B.O.D. was 3.1 mg/l and 4.8 mg/l respectively, the values for B.O.D. remained essentially constant at about 1.5 mg/l. Thus the distribution at this location followed the same pattern as the harbor area with lower D.O. and lower B.O.D. at the 25 foot level than at the five foot level. In addition, the B.O.D. values at five feet were generally higher than in the harbor area but D.O. was also higher.

Station A-1 at the mouth of the Alafia River on the eastern shore of the Bay showed the most marked variation in D.O. and B.O.D. during the field investigations. The minimum average monthly value at five feet was 3.1 mg/l during August 1967. This value was also associated with a minimum B.O.D. of 2.3 mg/l. The maximum B.O.D. value of 12.6 mg/l occurred during March 1967. Dissolved oxygen during this period was 9.6 mg/l. The maximum dissolved oxygen occurred one year later in March 1968. The D.O. of 11.5 mg/l was associated with a B.O.D. value of 9.1 mg/l. At 20 feet, the minimum D.O. of 1 mg/l was observed in July 1967 compared with a value of 3.4 mg/l at five feet during the same period. The B.O.D. was fairly constant between 2 and 3 mg/l from April 1967 to February 1968 exhibiting none of the variation observed at the five foot level. The B.O.D. at 20 feet did increase to a maximum of 5.4 mg/l during March 1968. The same pattern of significantly different D.O. and B.O.D. values at five feet and 20 feet during the summer as well as the anomaly of less B.O.D. and less D.O. at the lower depth was observed in the channelled areas throughout the entire system.

About 300 feet off the western shore in the upper part of the Bay where the most intense odors had been reported, D.O. was never less than 5.1 mg/l on a monthly average basis (station B-8). Therefore, the odor problem is not a direct function of soluble and suspended organic material depleting D.O. and causing anaerobic decomposition to occur.

The most critical concentrations of dissolved oxygen occur during the summer months of July, August and September. Figure 9.1 shows that for the period of August 29 through September 1, 1967 the period of intensive survey II-B, dissolved oxygen was depleted at the 25 foot depth in the harbor area and reached only 0.9 mg/l at the 25 foot depth in the lower Bay (station B18B). At the five foot depth, D.O. was less than 2 mg/l in the harbor area and rose to only 4.8 mg/l in the lower Bay (station B18T). With a five day B.O.D. of only 1 mg/l and a deoxygenation constant (k_1) of 0.08/day as measured by long term B.O.D. laboratory tests, and ultimate soluble B.O.D. of 1.66 mg/l can be expected at the 25 foot depth. This demand is not sufficient to explain the depleted dissolved oxygen at the lower depth and it was concluded that additional oxygen demand was being exerted by benthic deposits.

To evaluate this hypothesis, 95 bottom samples were collected throughout Hillsborough Bay during January 1968. These samples were analyzed for organic carbon, total Kjeldahl nitrogen and phosphorus. The locations of sampling stations used for this survey are shown in Figure 9.2 and the data are shown in Appendix Table A.10.

The distribution of organic carbon (O.C.) throughout Hillsborough Bay is shown in Figure 9.3 in ranges of 0-0.5%, 0.5-1.0%, 1.0-3.0% and greater than 3.0% organic carbon by weight. This distribution illustrates the effects of waste loads discharged to Hillsborough Bay on the deposition of benthic deposits. The organic carbon composition of Hillsborough Bay benthic deposits, expressed as a percentage of the entire Bay bottom, excluding Garrison Channel and McKay Bay, were: 16% of the bottom area contained greater than 3.0% by weight; 33% contained between 1.0 and 3.0% by weight; 21% contained between 0.5 and 1.0% by weight; and 30% of the Bay bottom contained less than 0.5% by weight. Those bottom areas of Hillsborough Bay highest in organic carbon content ($>$3.0% by weight) share three similar characteristics: 1) they are associated with waste inputs (Tampa and MacDill Air Force Base sewage treatment plants, the Hillsborough and Alafia Rivers), 2) they occur in areas where the tidal currents are lowest, and 3) they occur where the water depth is ten feet or greater, e.g., the channelled sections.

Theoretical Oxygen Demand (T.O.D.) is the demand which would be exerted by the benthic material if all the carbon and nitrogen were stabilized. These values were calculated stoichiometrically from the following formula:

$$\text{T.O.D. (mg/dry g of sediment)} = 2.67\,C + 4.57\,N$$

where

C = organic carbon as carbon and

N = total Kjeldahl nitrogen as nitrogen (11)(12)

T.O.D. ranged from three to 200 mg/g throughout the Bay. The high values occurring in areas where organic carbon is highest ($>$ 3.0% by weight) and generally following the distribution of organic carbon are presented in Figure 9.3.

A laboratory oxygen uptake study was done to measure the magnitude and rate of oxygen utilized in the stabilization of resuspended benthic material and comparative results are shown in Table 9.1. All materials exerted an immediate demand upon resuspension. The magnitude of this demand was 29% of the five day demand after the immediate demand, a linear rate of demand was established which was directly related to the organic carbon content. After five days the total five day demand was similarly related to organic carbon content.

Thus, the effect of resuspended bottom material on the oxygen resources is dependent upon the time the material stays in suspension, strength of the organic material, and amount of material resuspended. The

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(11) Effects of Polluting Discharges on the Thames Estuary, Department of Scientific and Industrial Research Water Pollution Research Technical Paper No. 11 London, 1964.

(12) Organic Carbon — Organic Nitrogen Ratios of Sediments in a Polluted Estuary, J.H. Finger and T.A. Wastler, Journal of Water Pollution Control Federation, February 1969.

Hillsborough Bay Technical
Assistance Project

Table 9.1

OXYGEN UTILIZED BY BENTHIC DEPOSITS

Range % O.C.	No. of Samples	Mean % O. C.	Mean % O.N.	Mean T. O. D.	Mean Immediate Demand mg/g	Mean 5-Day Demand mg/g	Mean Rate (After Immediate) mg/g/day
0 - 0.5	3	0.23	0.01	6.7	0.47	1.63	0.26
0.5 - 1.0	3	0.81	0.03	23.0	0.97	3.27	0.47
1.0 - 3.0	9	1.72	0.13	51.9	1.39	4.29	0.58
>3.0	8	4.02	0.35	136.8	2.68	10.68	1.45

O.C. = Organic carbon
O.N. = Organic Nitrogen
T.O.D. = Theoretical Oxygen Demand

rate of oxygen utilization, after the immediate oxygen demand, is dependent upon the percentage of organic carbon in the benthic material.

Field measurements of benthic oxygen uptake were attempted using an in situ benthic respirometer. The results of these measurements are summarized below:

Organic Carbon % by weight	Benthic Oxygen Uptake g O_2/m^2/day	T.O.D. mg/l
0.16	2.2	6
0.30	1.1	9
3.96	1.9	127
5.66	5.8	170

The benthic oxygen uptake rates were adjusted from field temperatures to 20°C using the temperature correction factor of 6.5% per °C. As with the laboratory studies, there was an immediate oxygen uptake associated with each measurement. This immediate demand was highest for benthic deposits with the highest values of O.C. and T.O.D. The rates tabulated above were calculated excluding this immediate effect. However, it should be realized that if the benthic material is resuspended by wind and wave action, the benthic oxygen uptake rates would be much higher than under quiescent conditions.

Based on the distribution of organic carbon in Figure 9.3 and the uptake rates shown above, the benthic oxygen demand is estimated to be 16,500 pounds/day in Hillsborough Bay. This does not account for immediate demand due to resuspension.

It is clear that the Bay bottom is covered by a significant amount of organic benthic material and that this material does exert a substantial demand on the oxygen resources of Hillsborough Bay. This condition accounts for the excessively low dissolved oxygen values at the deeper levels. Since the soluble B.O.D. is not sufficient to cause this depletion, the principal source of oxygen demand is the satisfaction of benthic deposits which result primarily from the sediment inflow from the Hillsborough and Alafia Rivers, the discharge of the Tampa sewage treatment plant, and the decomposition of settled phytoplankton.

On September 5, 6 and 7, 1967, along the western shore where the most intensive odors have been reported, average dissolved oxygen remained above 2 mg/l and was greater than 4 mg/l below Davis Island (Figure 9.4). However, there were wide diurnal variations typical of the effect produced by phytoplankton (Figure 9.5). Maximum values exceeded 10.0 mg/l at all stations and occurred at about 1730 hours daily during the survey. Minimum values reached zero at two stations and were less than 3.0 mg/l at all other stations and occurred at approximately 0400 hours daily. Five day B.O.D. was as high as 5.3 mg/l at station B24. With a deoxygenation rate (k_1) of 0.1/day this would produce an ultimate B.O.D. of 7.75 mg/l which together with phytoplankton respiration of 1.4 mg/l was sufficient to deplete dissolved oxygen. Since the B.O.D. samples were not filtered, a large portion of that five day B.O.D. was due to respiration and decay of plankton cells.

A continuing study of primary productivity in the Bay was conducted from August 1967 to August 1968 using the light-dark bottle method. Duplicate measurements were made on the initial bottles, light bottles and dark bottles at the surface, one meter and two meter depths at each station. Eight stations were sampled with stations B10, B12 and B18 being sampled twice per month and stations B1, B8, B14, B22 and B23 being sampled once per month.

Primary productivity as based on the gross photosynthesis values can be divided into river mouth, central bay and lower bay zones. The river mouth zone is represented by station B1 at the mouth of the Hillsborough River. The annual mean gross photosynthesis value at this station is 2.0 g $O_2/M^3/Day_{24}$. The central bay stations (B10, B12, B18) had an annual mean of approximately 4.9 g $O_2/M^3/Day_{24}$ and the lower stations (B22, B23) had an annual mean of approximately 3.1 g $O_2/M^3/Day_{24}$. Gross photosynthesis at stations B10 through B18 (central bay zone) had annual means that ranged between 4.8 to 5.0 g $O_2/M^3/Day_{24}$ (Table 9.2). Therefore, throughout most of the bay (85%), primary productivity is about equal at any point.

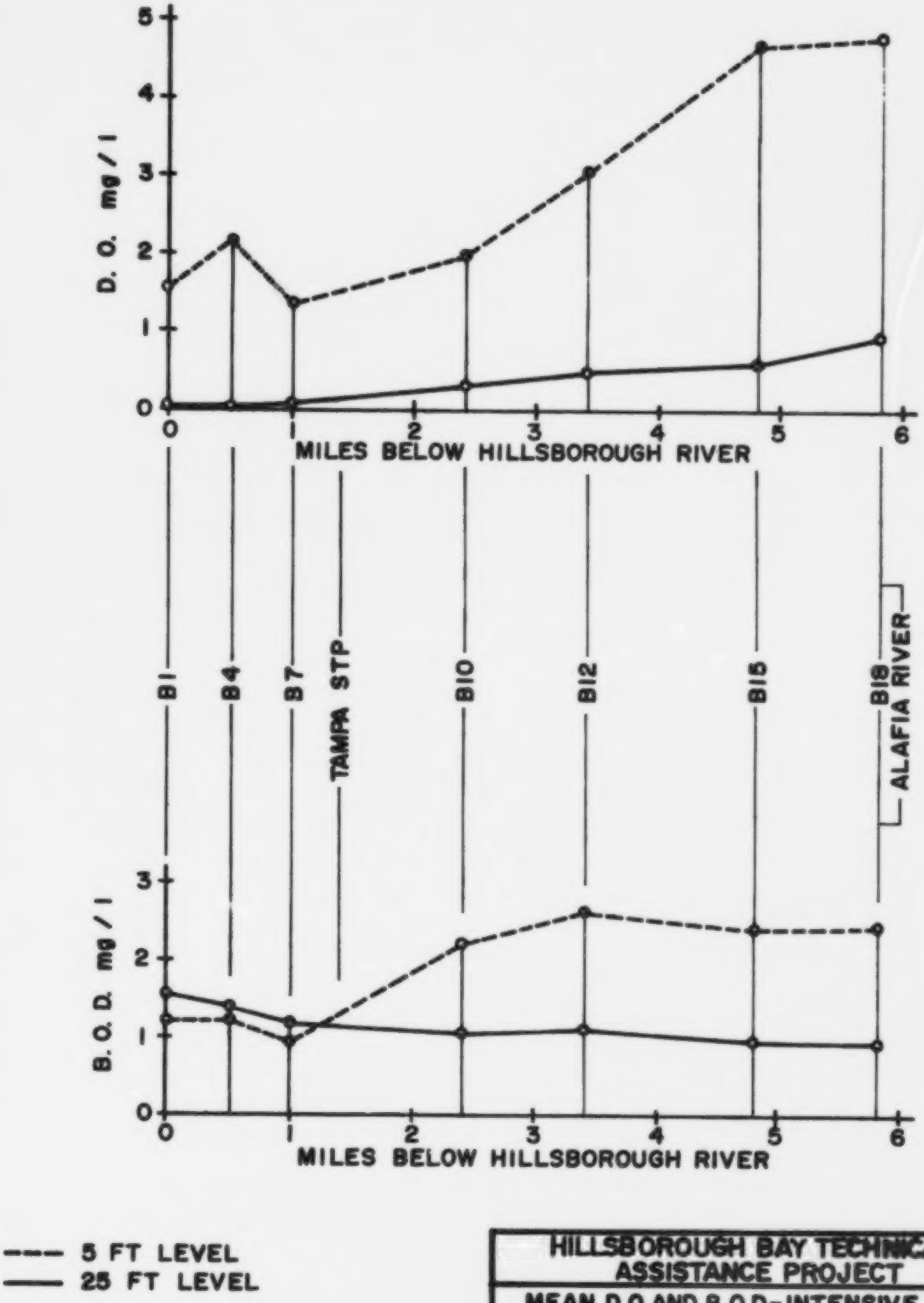
Hillsborough Bay Technical Assistance Project

PRIMARY PRODUCTIVITY STUDY

Table 9.2

Respiration (R) and Gross Photosynthesis (Pg) per Station from August 1967 to August 1968 as g $O_2/M^3/Day_{24}$

Station	Respiration	Gross Photosynthesis
B1	0.46	2.02
B10	1.53	4.88
B12	1.49	4.78
B18	1.94	5.00
B22	1.09	3.07
B23	1.15	3.18
Average	1.28	3.82



HILLSBOROUGH BAY TECHNICAL
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MEAN D.O AND B.O.D-INTENSIVE II B
MAIN CHANNEL STATIONS

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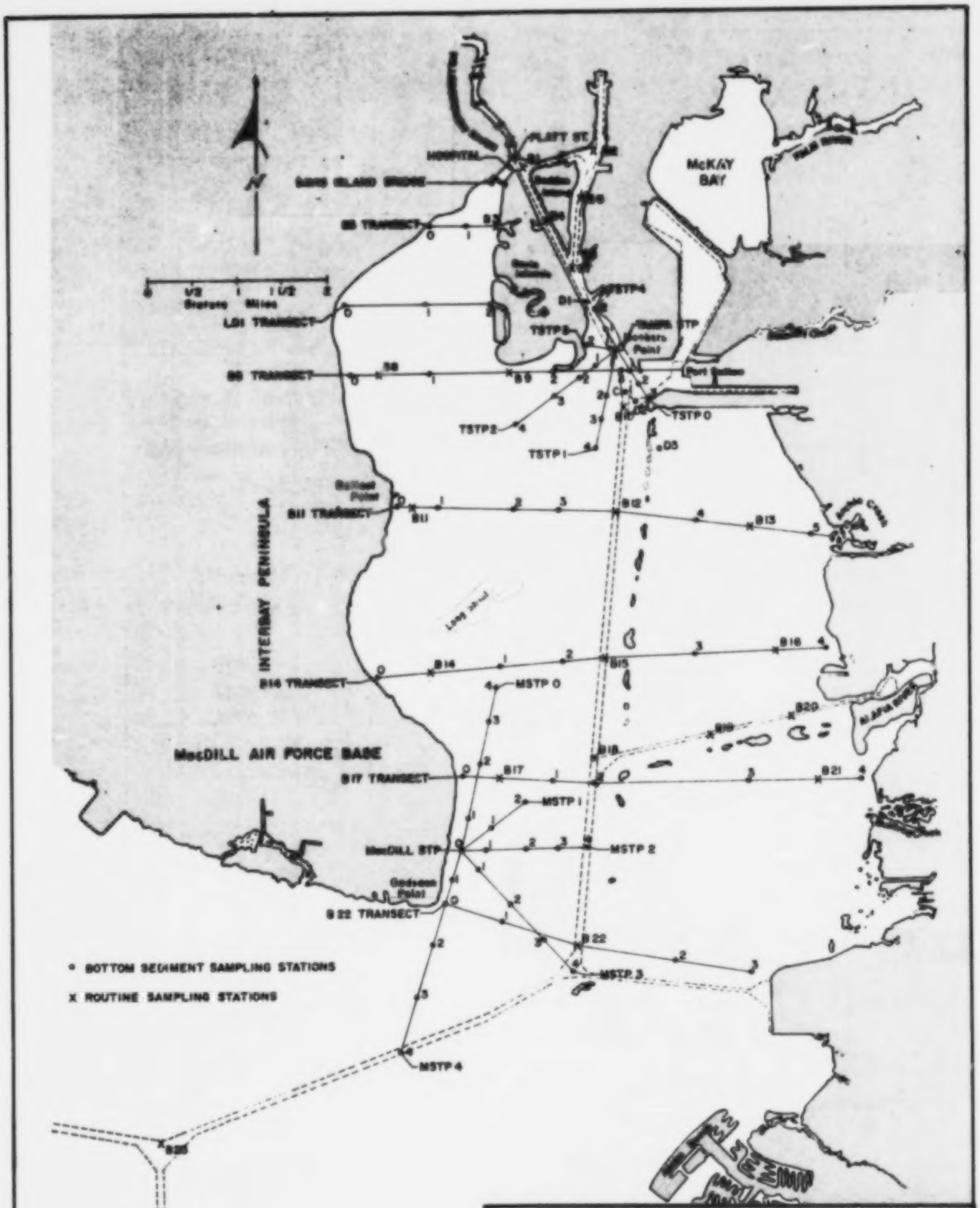
Southeast Water Laboratory Athens, Georgia

23-a

FIGURE 9.1


N
0
1/2
1
1 1/2
2
Statute Miles
PLATT ST.
HOSPITAL
DAVIS ISLAND BRIDGE
B5 TRANSECT
McKAY BAY
LD1 TRANSECT
D1
TSTP4
TSTP3
TAMPA STP
B8 TRANSECT
B8
B9
Port Sutton
TSTP0
TSTP2
TSTP1
D3
Ballast Point
B11 TRANSECT
B11
B12
B13
INTERBAY PENINSULA
Long shoal
B14 TRANSECT
B14
B15
B16
MSTP 0
B19
B20
MacDILL AIR FORCE BASE
B18
B17 TRANSECT
B17
B21
MSTP 1
MacDILL STP
MSTP 2
Gadsden Point
B22 TRANSECT
B22
MSTP 3
MSTP 4
B23
• BOTTOM SEDIMENT SAMPLING STATIONS
X ROUTINE SAMPLING STATIONS

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

BOTTOM SEDIMENT SAMPLING STATIONS

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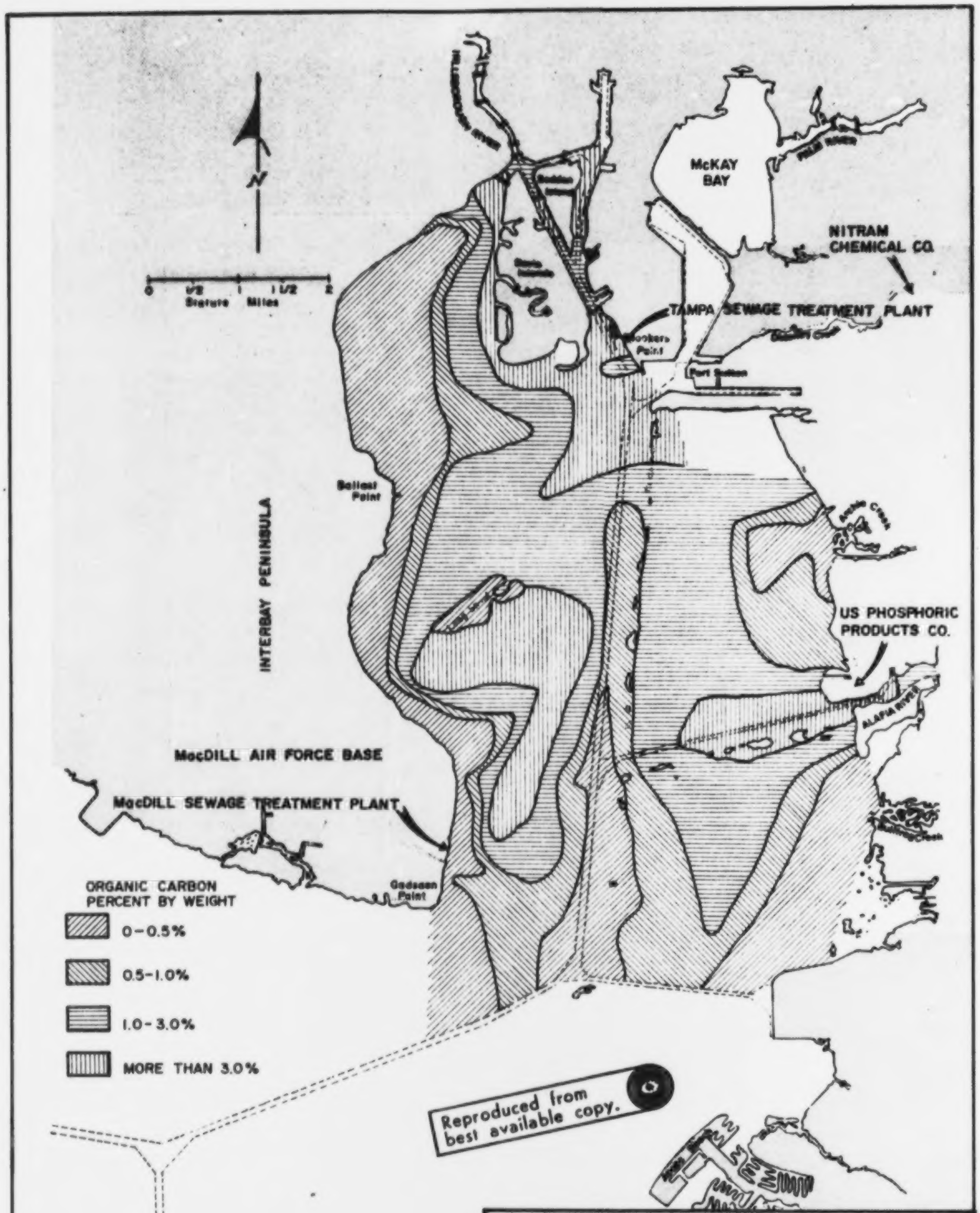
FIGURE 9.2

23-b


N
0 1/2 1 1 1/2 2
Statute Miles
HILLSBOROUGH RIVER
McKAY BAY
PALM RIVER
NITRAM CHEMICAL CO.
TAMPA SEWAGE TREATMENT PLANT
Hookers Point
Port Sutton
Ballast Point
INTERBAY PENINSULA
US PHOSPHORIC PRODUCTS CO.
ALAFIA RIVER
MacDILL AIR FORCE BASE
MacDILL SEWAGE TREATMENT PLANT
Gadsden Point
ORGANIC CARBON PERCENT BY WEIGHT
0-0.5%
0.5-1.0%
1.0-3.0%
MORE THAN 3.0%

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HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

ORGANIC CARBON DISTRIBUTION IN BOTTOM SEDIMENTS

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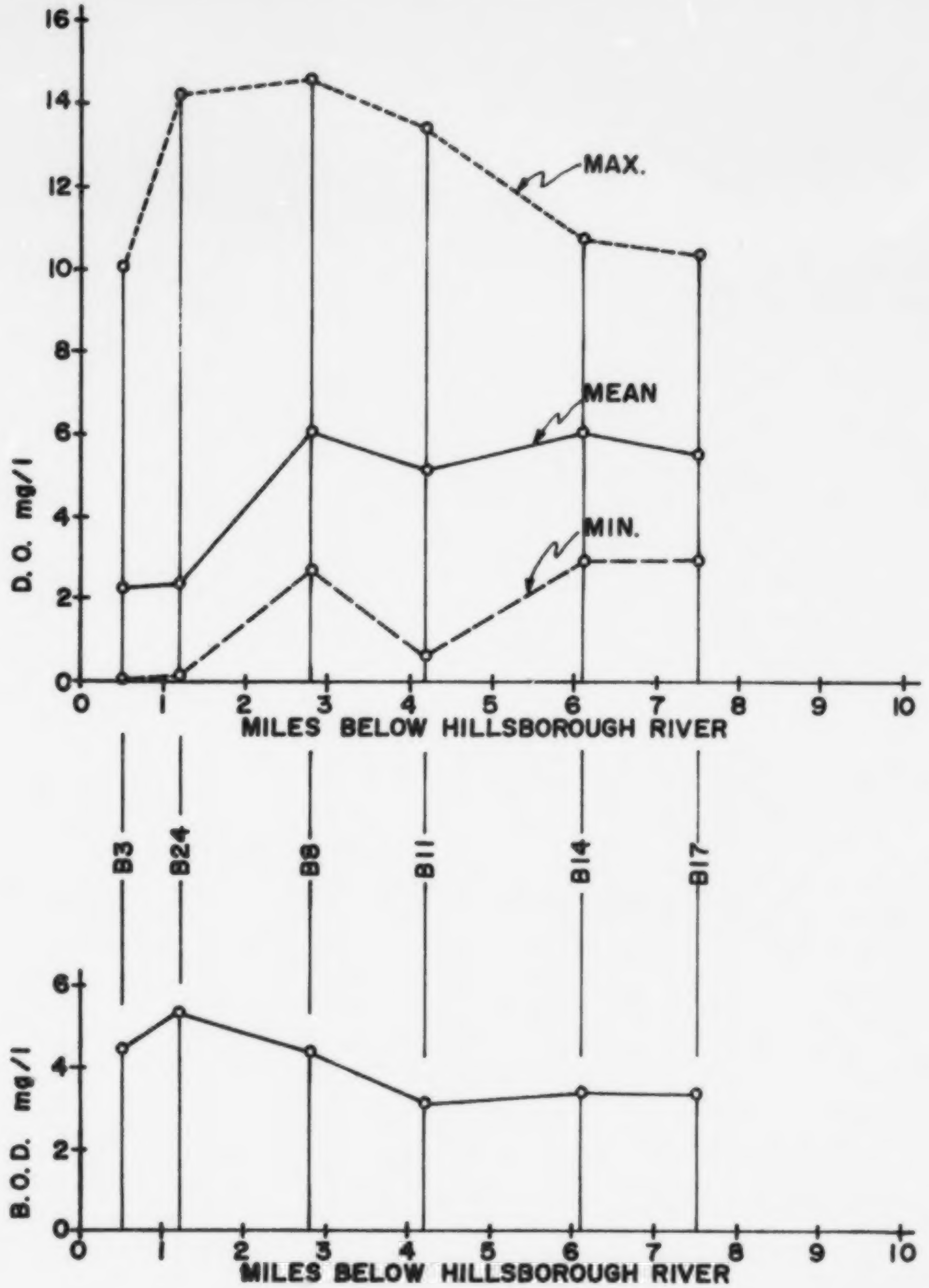
FIGURE 9.3

23-C



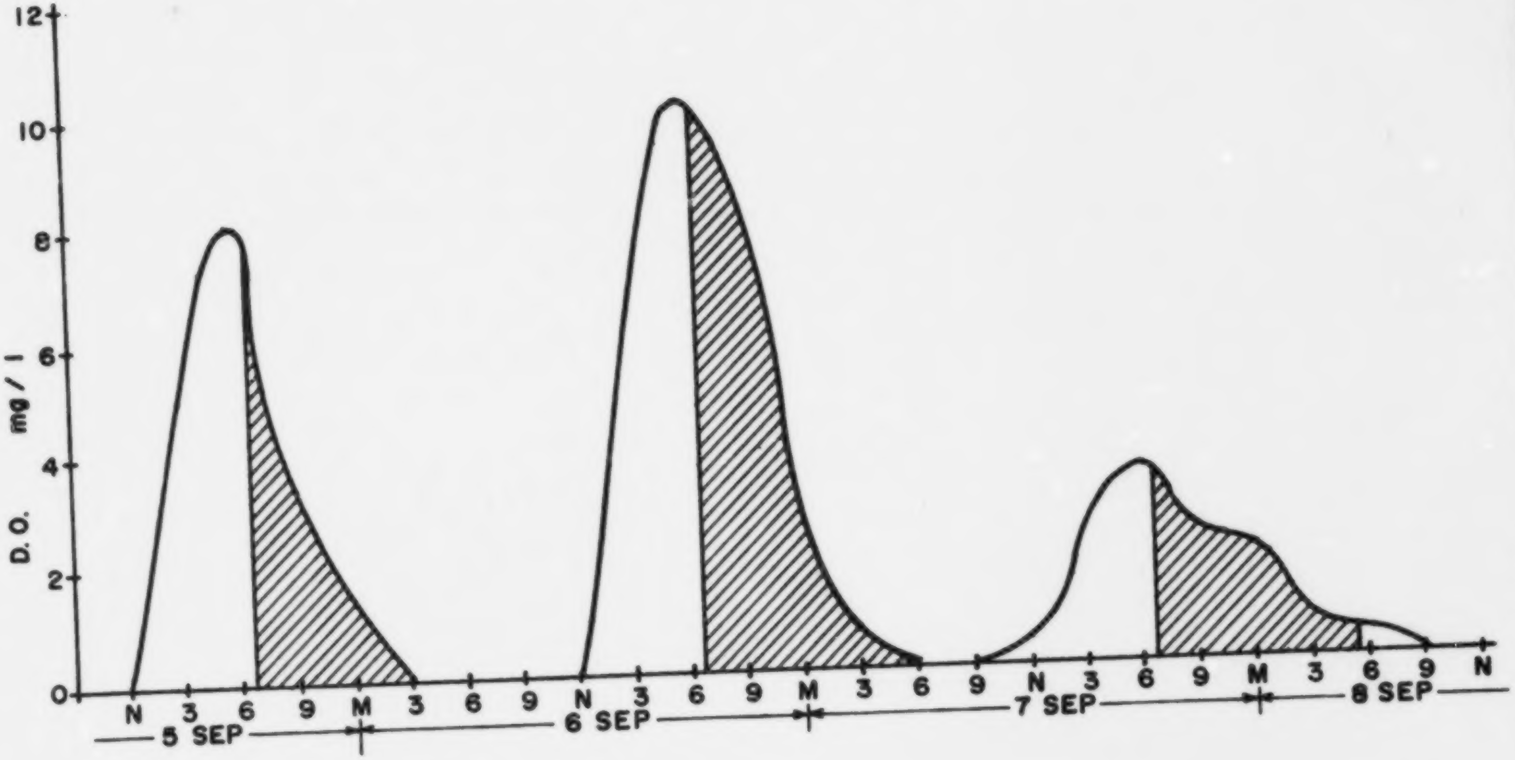
HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

MEAN D.O AND B.O.D.-INTENSIVE II C
WEST SHORE STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

23-d

FIGURE 9.4



▨ NIGHT

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

DJURNAL D.O. VARIATIONS
STATION B3—INTENSIVE II C

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FIGURE 9.5

23-E

At least three conditions could be responsible for the lower value at B1 (river mouth zone): 1) the freshwater inflow down the Hillsborough River dilutes the phytoplankton, 2) the organisms cannot tolerate the lowered chlorosity, and 3) the presence of undetermined algacides from water treatment up the river. Stations B22 and B23 (lower bay zone) are subject to tidal mixing with Tampa Bay water which supports a lower phytoplankton population.

Photosynthesis varied widely in Hillsborough Bay during the survey. Figure 9.6 shows the seasonal variation in mean gross photosynthesis at the six comparable stations. The gross photosynthesis was 5.13 mg $O_2/M^3/Day_{24}$ in October and decreased to 1.69 in December and then began a gradual increase to 8.09 in August 1968, at which time the study was terminated.

Oxygen production per day has been calculated for the river mouth, central bay and lower bay zones for the summer and winter periods. The area of each zone was: river mouth, 324 acres; central bay 20,000 acres; and lower bay, 3,230 acres. Since primary productivity occurred principally in the upper six feet of the Bay as determined by light penetration measurement, this depth was used to calculate the volume of the three zones. An average of the net photosynthesis values from April through September represent the summer period and the October through March values are averaged for the winter period. Listed below are the pounds of oxygen produced per day based on net photosynthesis (oxygen produced minus oxygen respired) in the three zones for both the summer and winter periods:

OXYGEN PRODUCTION – Pounds per Day

	River Mouth Zone	Central Bay Zone	Lower Bay Zone
Summer	14,230	1,740,000	309,200
Winter	15,230	1,440,000	139,800

Near the river mouth the net oxygen production is higher in the winter than the summer because the environment is more stable in the winter. The lower temperatures during the winter period tend to lower oxygen production, but environmental conditions such as chlorosity and stained waters tend to make the production even lower during the summer period. Over the entire survey period, the gross oxygen production was 1,327,000 pounds per day and respiration amounted to 445,000 pounds per day. Net photosynthesis was 882,000 pounds per day. (Table 9.2)

Oxygen demand from the three major sources in Hillsborough Bay are 78,000 pounds per day from waste sources, 16,500 pounds per day from benthic deposits and 445,000 pounds per day from respiration of plankton. This respiration of plankton accounts for more than 82% of the oxygen demand in Hillsborough Bay. However, this demand is offset by photosynthesis and, on a net basis, soluble organic material assumes the greatest importance.

These productivity data account for the high D.O. and B.O.D. values observed in the open Bay and along the western shore during the summer months. Oxygen variation in these areas is primarily a function of phytoplankton production and respiration. It has been determined that the phytoplankton growth contributes an average of 1.5 g of organic carbon/cubic meter of Bay volume/day throughout the top 2 meters of the Bay. This amounts to approximately 61,000 pounds/day of organic carbon.

Nitrogen and Phosphorus

In order to show monthly variations in condition of phytoplankton chlorophyll was determined at 11 stations throughout the Bay. To demonstrate the monthly variation in chlorophyll a, station B11 was arbitrarily selected and the data presented in Figure 9.7. This curve shows the chlorophyll a value low in August 1967 due to high inflow of freshwater killing and diluting the phytoplankton. The freshwater imparted a stain and the weather during this month was extremely cloudy thereby limiting photosynthesis. Chlorophyll a increased from August to November 1967 and then began to decrease to a low in February 1968. An increase began in March and continued until July 1968.

The mean of 320 chlorophyll a determinations at 11 stations throughout the Bay was 35.15 ug/l. This indicates the Bay is at a high trophic level with a large plant biomass caused by an excess of nutrients. Chlorophyll a samples taken in June through July 1968 in Tampa and Hillsborough Bays yield values of 12.41 ug/l for Tampa Bay and 48.76 ug/l in Hillsborough Bay. This significant difference again points to the excessive growths in Hillsborough Bay. This phenomenon is the result of the build-up of primary nutrients (nitrogen and phosphorus) in the Bay. In the following discussion all phosphorus is reported in mg/l as P and all nitrogen compounds are reported in mg/l as N.

Comparisons of filtered and unfiltered phosphate determinations indicated that greater than 95% of the concentration was in a soluble form. All concentrations in the subsequent discussion refer to total phosphate. However, for all practical purposes, these figures can be assumed to represent soluble phosphate as well.

Phosphate distribution based on the mean concentration for the period of study is shown in Figure 9.8. A mean survey value of 9.65 mg/l was observed at station A1 (U.S. Highway 41 Bridge) on the Alafia River. As previously noted approximately 43,470 pounds/day of phosphates (as P) are discharged from the Alafia River and another 8,810 pounds per day are discharged from U.S. Phosphoric Products. Together these two sources account for 93.8% of the total phosphorus input into Hillsborough Bay from waste sources. The phosphate gradient is pronounced around these two sources, approximately 1 mg/l per mile. The lowest values are found in the northwestern portion of the Bay near Bayshore Boulevard (2.85 mg/l) and in Tampa Bay (2.34 mg/l), with phosphate concentrations slightly lower in winter than in summer (see Table 9.3). This is the result of lower flows in the Alafia River and consequently lower mass input of phosphate during the winter. The pattern of distribution does not change. The minimum total phosphate concentration observed occurred at station B24 on August 23, 1967 and was 0.165 mg/l as P. Examination of phosphate concentrations at three and four hour intervals during August and September of 1967 reveal no variation in concentration attributable to tidal action.

Studies by the University of Florida on the unpolluted waters of the Waccasassa Estuary show phosphate concentrations of 0.03 mg/l.(13) That study concluded that the Waccasassa Estuary is nutrient limited in that it does not presently exhibit maximum photosynthesis. However, nitrogen rather than phosphorus was concluded to be the limiting nutrient. Further, it was concluded that the Waccasassa Estuary was a balanced ecological system. Thus, it can be hypothesized that, in this area, a phosphate concentration of 0.03 mg/l is sufficient to maintain a diversified ecology without limiting primary productivity. Concentrations of phosphate observed in Hillsborough Bay are approximately 100 times higher than the level reported in the Waccasassa Estuary.

Ammonia exhibits a gradient along the longitudinal axis of the Bay. Mean concentrations at the five foot depth for the period of study are shown in Figure 9.9. Average concentrations of about 0.3 mg/l are predominant in the upper Bay and around the sewage treatment plant outfall and gradually decrease to 0.10 mg/l at the mouth of Hillsborough Bay. A peak of 0.45 mg/l as N was observed at station B3 on the west side of Davis Island and a minimum of 0.16 mg/l at station B8. A plot of mean monthly concentrations of ammonia, nitrate and Kjeldahl nitrogen at stations B3 and B8 are shown in Figures 9.10 and 9.11.

Hillsborough Bay Technical Assistance Project

Table 9.3

SEASONAL COMPARISON OF TOTAL PHOSPHATES

Station	Summer Months*	Winter Months*
A1	10.00	8.31
A6	18.92	31.97
B1	2.54	2.84
B6	3.45	3.34
B7	2.90	2.84
B8	3.23	2.95
B10	3.51	3.04
B11	3.21	3.01
B12	3.47	3.23
B14	3.31	3.06
B17	3.31	3.00
B18	3.67	2.57
B22	3.20	2.90
B23	2.56	2.03
B24	2.81	2.86

*Summer months – July, August, September 1967.
Winter months – December 1967, January, February, March 1968.

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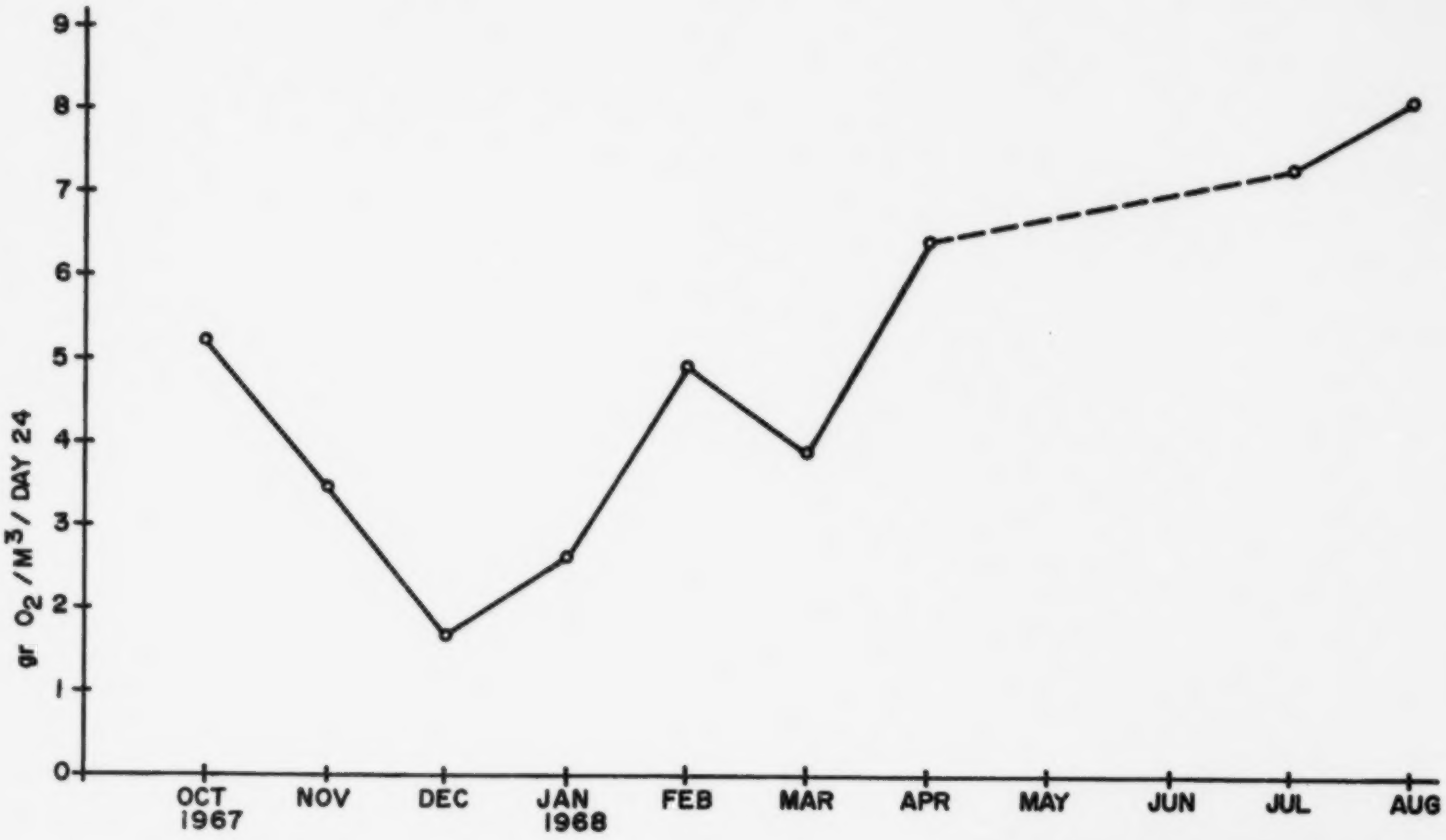
(13) A study of Estuarine Pollution Problems on a Small Unpolluted Estuary and a Small Polluted Estuary in Florida, T. Saville, University of Florida Engineering and Industrial Experiment Station, Gainesville, Florida, August 1966.



HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

MEAN MONTHLY GROSS PHOTOSYNTHESIS
STATIONS B1, B10, B12, B18, B22, B23

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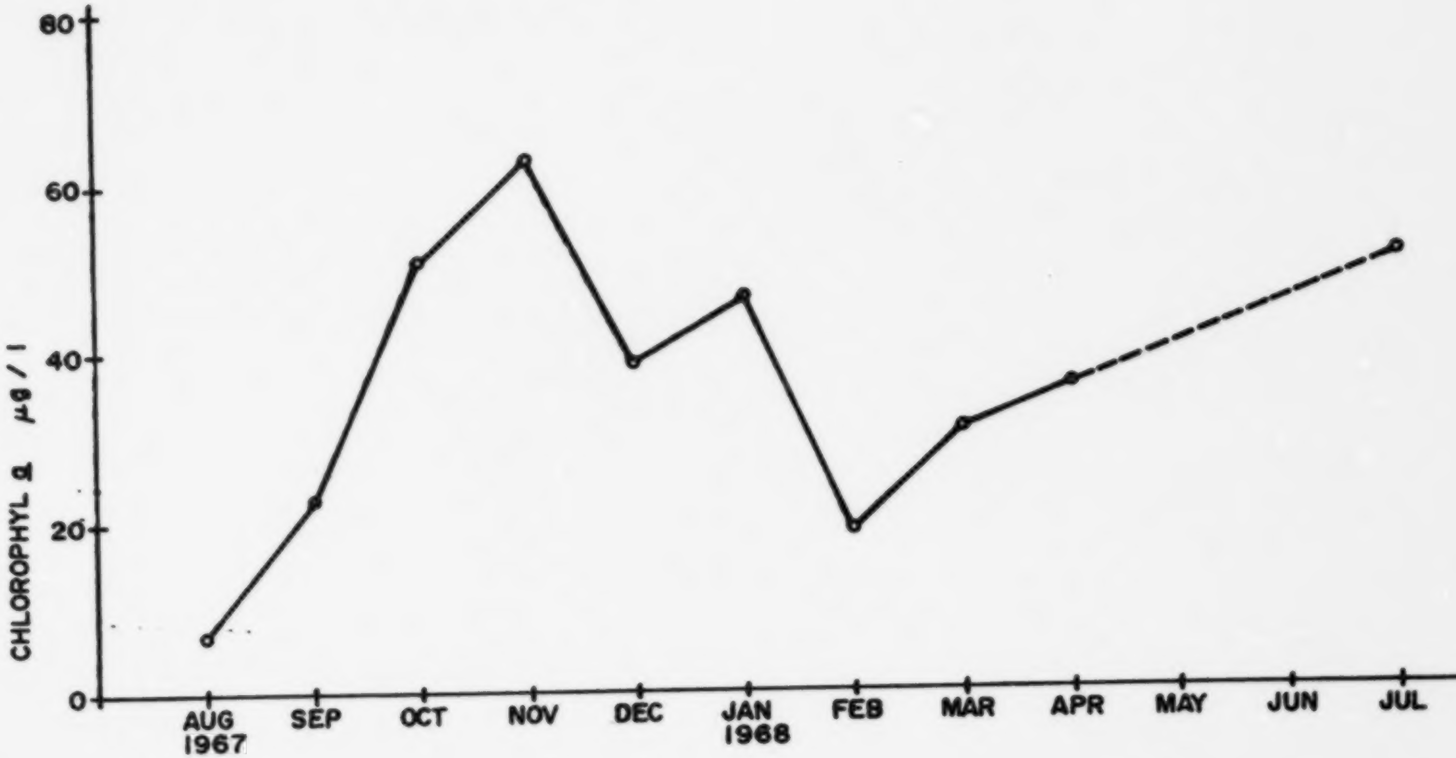
FIGURE 9.6



HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

MONTHLY MEAN CHLOROPHYLL a
STATION B11

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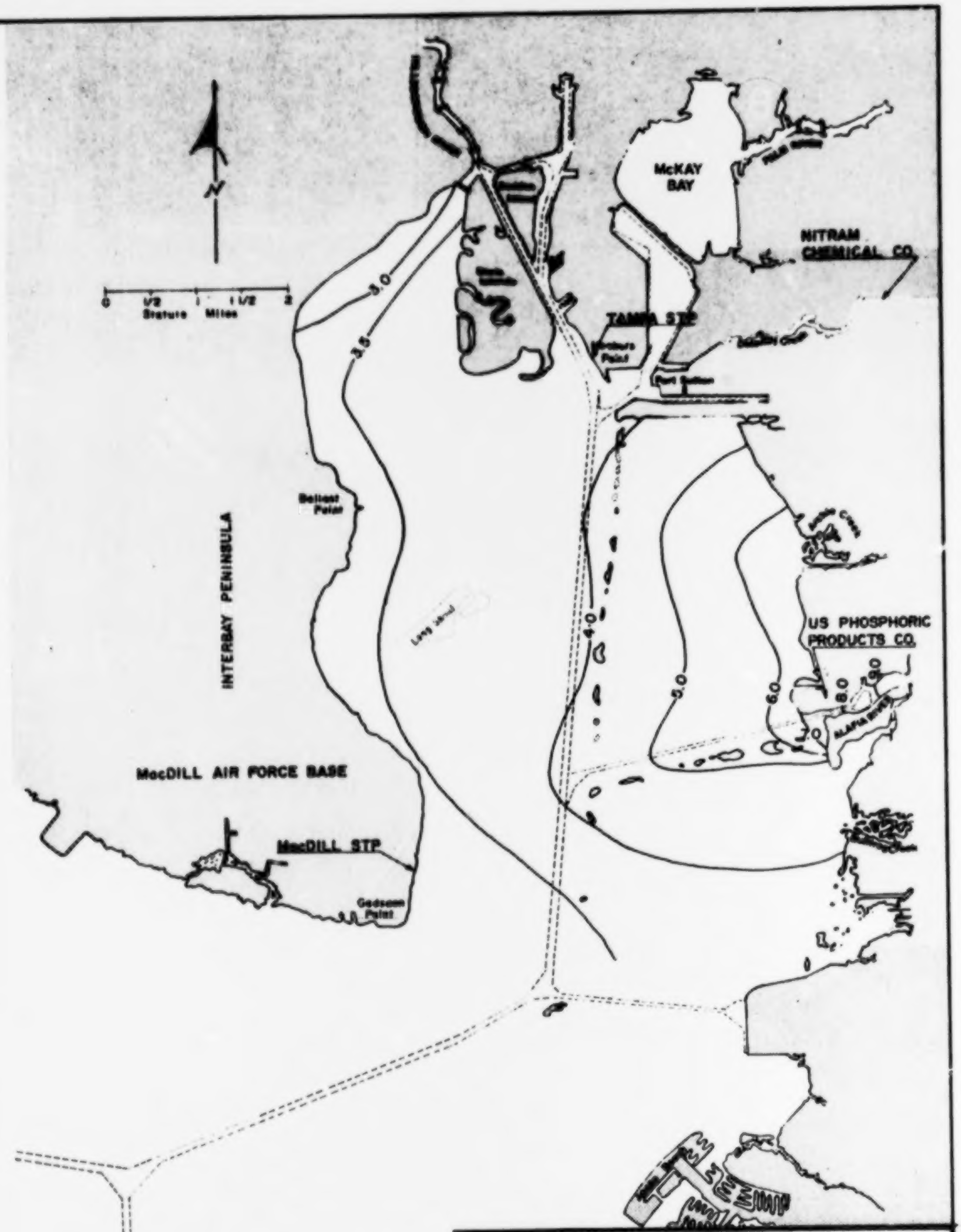
FIGURE 9.7

25-f


N
0
1/2
1
1 1/2
2
Statute Miles
McKAY BAY
NITRAM CHEMICAL CO.
TAMPA STP
Hookers Point
Port Sutton
3.0
3.5
4.0
5.0
6.0
7.0
8.0
9.0
Ballast Point
INTERBAY PENINSULA
US PHOSPHORIC PRODUCTS CO.
ALAFIA RIVER
MacDILL AIR FORCE BASE
MacDILL STP
Gadsden Point

PHOSPHATE CONCENTRATION mg/l as P
SURFACE SAMPLES
MEAN FOR PERIOD OF STUDY

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

PHOSPHATE CONCENTRATION

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FIGURE 9.8

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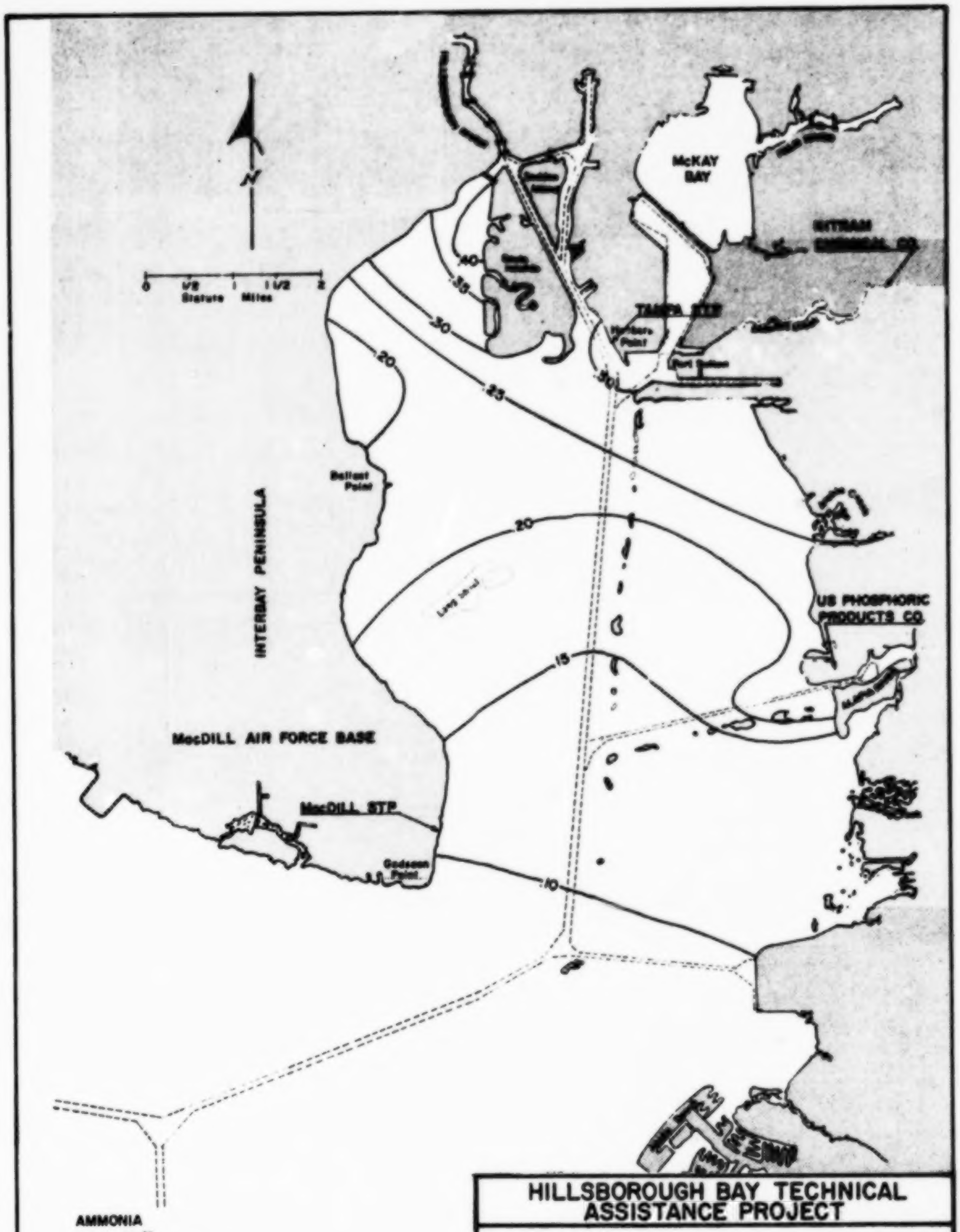
25-C


N
0 1/2 1 1 1/2 2
Statute Miles
McKAY BAY
NITRAM CHEMICAL CO.
TAMPA STP
Port Sutton
.40
.35
.30
.25
.20
.30
INTERBAY PENINSULA
Ballast Point
.20
Long Island
US PHOSPHORIC PRODUCTS CO.
.15
MacDILL AIR FORCE BASE
MacDILL STP
Gadsden Point
.10

AMMONIA
mg/l as N
SURFACE SAMPLES
MEAN FOR PERIOD OF STUDY

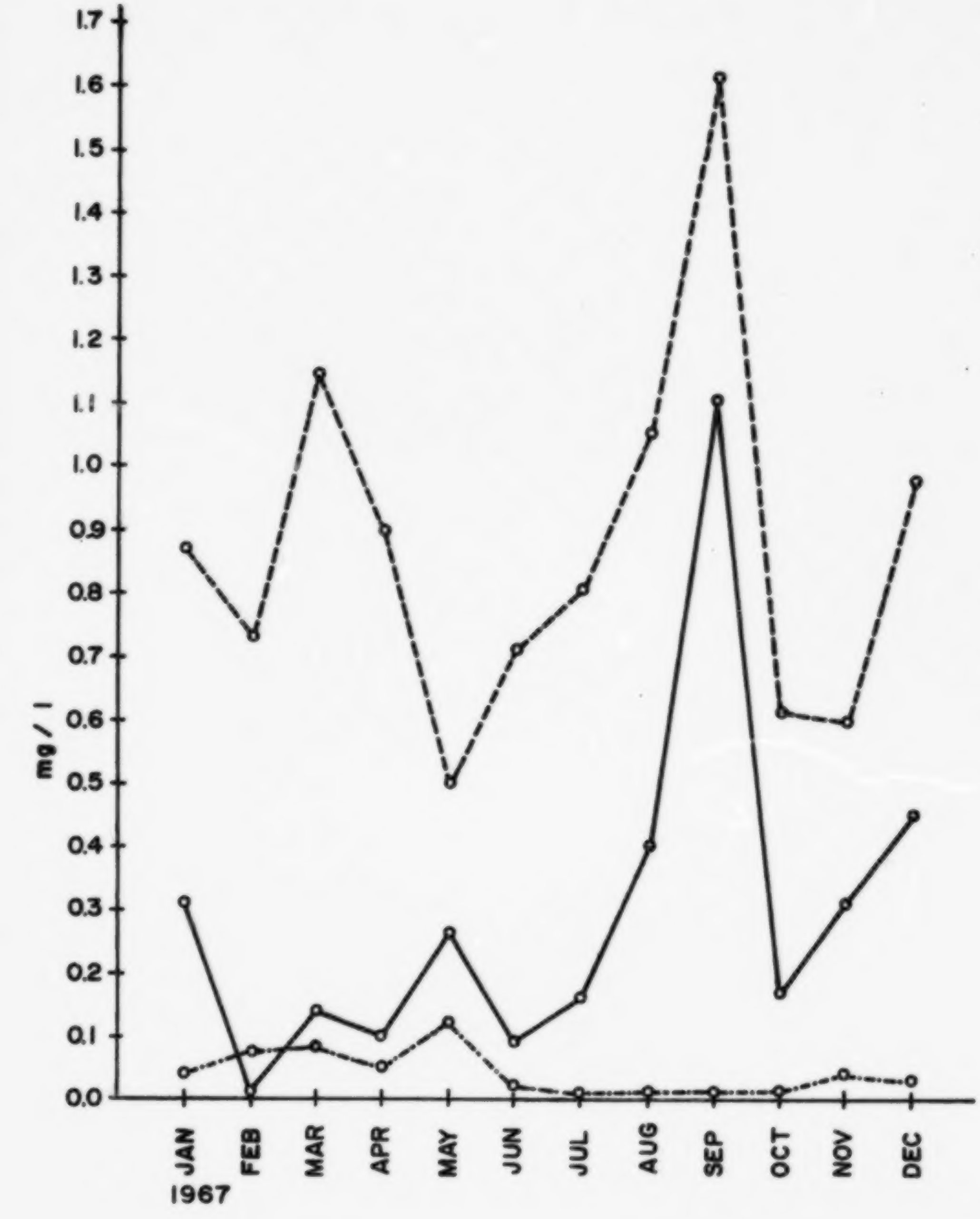
HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

AMMONIA CONCENTRATION

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

25-d

FIGURE 9.9



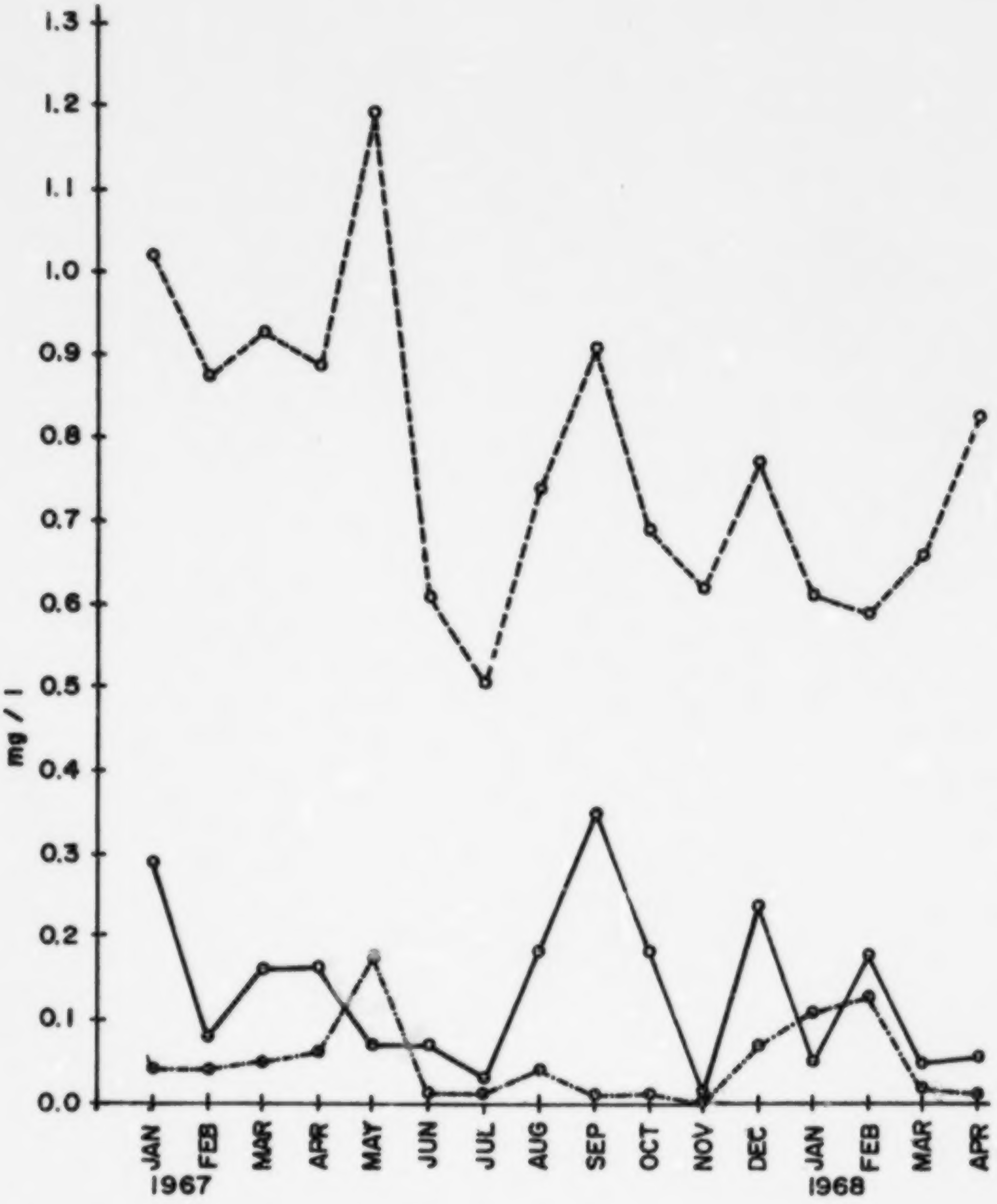
HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

MEAN MONTHLY NITROGEN CONC.
STATION B3

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

25-E

FIGURE 9.10



HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

MEAN MONTHLY NITROGEN CONC.
STATION B8

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

25-F

FIGURE 9.11

Construction of a parking lot adjacent to Tampa General Hospital was under way during the summer and fall of 1967. The increase in NH_3 and Kjeldahl at station B3 is attributed to the disturbance of bottom materials in the borrow area immediately adjacent to the station.

At station B8 (see Figure 9.11) the ammonia and nitrate follow the expected pattern. Ammonia decreased during winter and spring while nitrates increase due to the stabilization of decay products. In early summer, available nitrates are quickly used by blooming aquatic vegetation reducing the nitrates to a very low level (0.01 mg/l). Subsequent simultaneous growth and decay during the summer keeps nitrates at a low level while ammonia, indicative of the early stages of decay, increases. Organic nitrogen (Kjeldahl) in phytoplankton, suspended solids, and benthic materials, provides a continuous source of decay products in addition to the continuous addition of nitrogen compounds to the Bay from waste inputs. Even so, nitrate nitrogen is reduced to a very low level, 0.01 mg/l, during the late spring and summer. A corresponding drop in phosphate is observed at station B8 although concentration never falls below 1.7 mg/l and are therefore never limiting.

Total Kjeldahl nitrogen in benthic material varied from 0.02 to 0.4% by dry weight. It followed the same distribution pattern as organic carbon. The highest Kjeldahl nitrogen levels (0.2-0.4%) were associated with organic carbon of 3.0% and the lowest nitrogen levels (0.01-0.16%) were associated with organic carbon of 0.5% or less. (Figure 9.12).

Total phosphate in benthic material ranges from 0.04 to 4.97% by dry weight as shown in Figure 9.13. Highest concentrations are near the mouth of the Alafia River. Concentrations ranged from 1.6% at the U.S. Highway 41 Bridge (A-1) to 0.39% at the intersection of the Alafia and Main Ship Channels (B-18), with the highest value in the Bay of 4.97% (B-25) occurring at the mouth of the Alafia River. These concentrations are associated with the huge quantities of phosphates discharged from the Alafia River. The accumulation is due to precipitation of insoluble phosphates which make up 51.6% of the total phosphate at station A-1 but only 19% at station B-18. The other high phosphate concentration, 2.95% was found in Seddon Channel adjacent to the phosphate loading operation on Seddon Island (B-4).

This system is limited by available nitrate, further reduction of available nitrate and ammonia might be expected to further limit the growth of aquatic vegetation.

Fecal Coliform

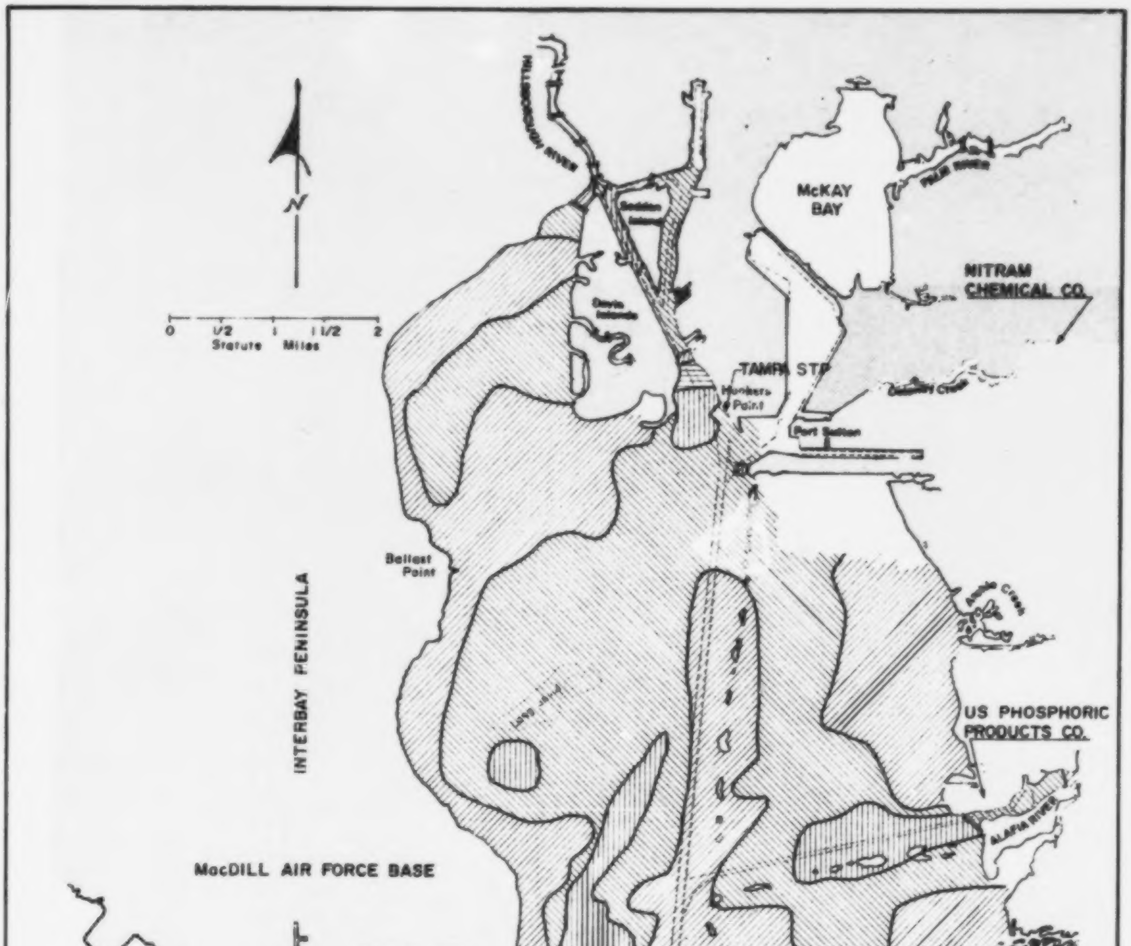
Fecal coliform data were collected as part of the weekly sampling program and intensive surveys from June through December 1967. The logarithmic mean of weekly data are presented in the Appendix Table A.11. The highest fecal coliform densities, 106,000 and 107,000/100 ml, were found near the Tampa sewage treatment plant outfall and are confined to the upper Bay and deep channel harbor area. The fecal coliform densities decrease in a radiating fan-like manner from the sewage treatment plant outfall in all directions (see Figure 9.14).

The logarithmic mean fecal coliform densities increase from the mouth of the Hillsborough River (190 to 260/100 ml), through Seddon and Sparkman Channels (260 to 460/100 ml) peak adjacent to the sewage treatment plant outfall (5240/100 ml), decrease rapidly to minimal values near the Alafia Channel (3 to 8/100 ml), and decrease to near zero at the Tampa Bay Control Station (1/100 ml). This main channel profile is shown in Figure 9.15.

A profile of the logarithmic mean fecal coliform densities for the Alafia stations is presented in Figure 9.16. The highest density, 62/100 ml, occurred at the U.S. Highway 41 Bridge and decreased to 2 to 10/100 ml just beyond the mouth of the Alafia River, increased slightly at the main channel junction (3 to 8/100 ml) and dropped to a minimal value (4/100 ml) just offshore of MacDill Air Force Base.

The logarithmic mean coliform densities along Bayshore Boulevard (see Figure 9.17) ranged from 190 to 260/100 ml at the mouth of the Hillsborough River, dropping rapidly to 26/100 ml at station B24 (between Davis Island and Bayshore Boulevard), and decreasing to minimal values of 6/100 ml, 4/100 ml at stations B11 (Ballast Point), B14 (MacDill Air Force Base port facility), and B17 (Alafia River range marker).

From these data, it is concluded that the Tampa sewage treatment plant is the only significant source of fecal coliform pollution in the Bay. Station B9 with a fecal coliform density of 1560/100 ml is immediately adjacent to the Davis Island seaplane basin where a public beach is located. Almost all the stations in the upper and western Bay have fecal coliform densities greater than the recommended 200/100 ml for primary contact recreation.


N
0 1/2 1 1 1/2 2
Statute Miles
HILLSBOROUGH RIVER
Davis Islands
McKAY BAY
PALM RIVER
NITRAM CHEMICAL CO.
TAMPA STP
Hookers Point
Port Sutton
INTERBAY PENINSULA
Ballast Point
US PHOSPHORIC PRODUCTS CO.
ALAFIA RIVER
MacDILL AIR FORCE BASE
MacDILL STP
Gadsden Point
ORGANIC NITROGEN PERCENT BY WEIGHT
0-0.1%
0.1-0.3%
0.3-0.5%
MORE THAN 0.5%

HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

ORGANIC NITROGEN DISTRIBUTION
IN BOTTOM SEDIMENTS

U.S. DEPARTMENT OF THE INTERIOR
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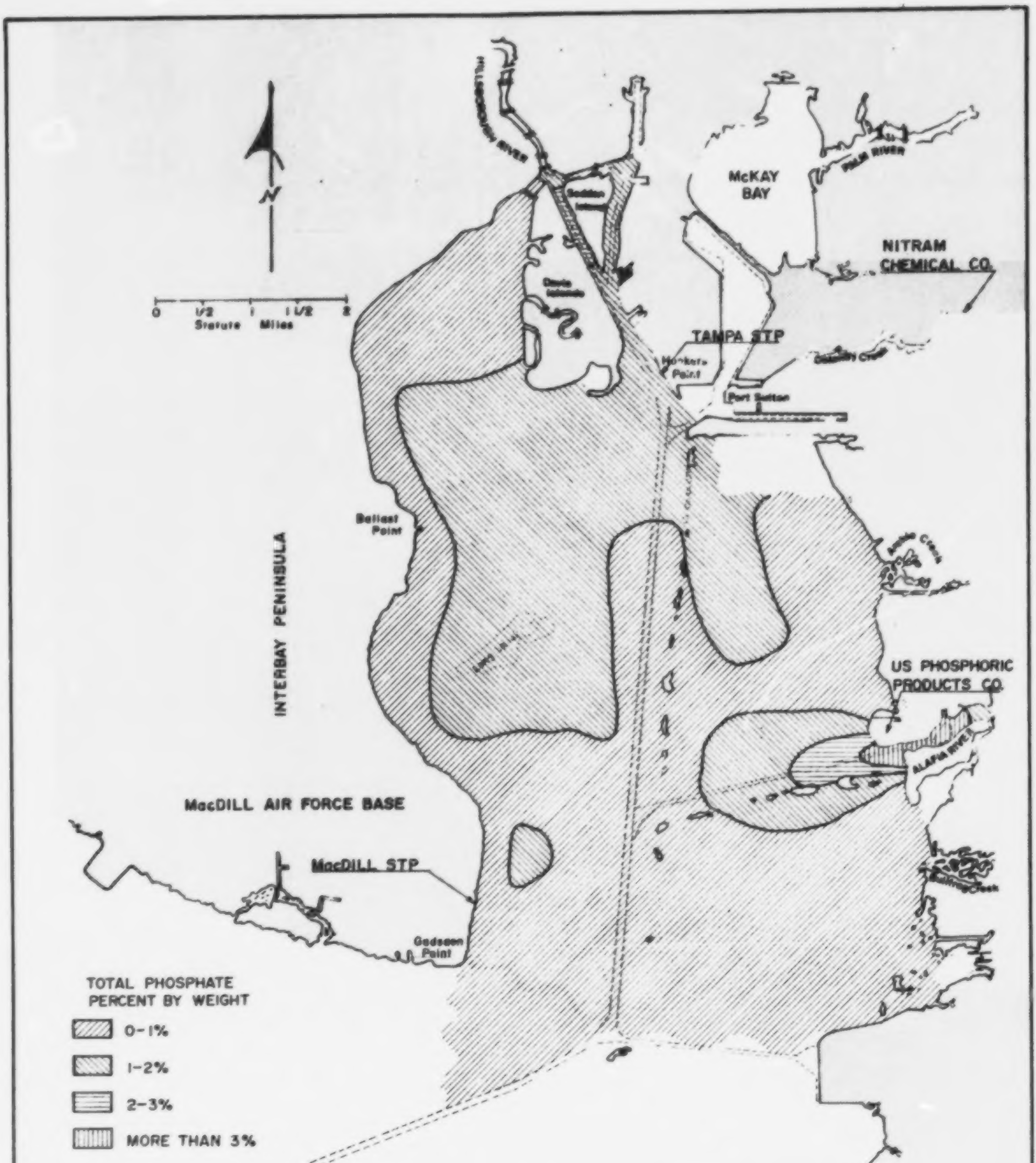
Southeast Water Laboratory Athens, Georgia

FIGURE 9.12


N
0 1/2 1 1 1/2 2
Statute Miles
HILLSBOROUGH RIVER
Davis Islands
McKAY BAY
PALM RIVER
NITRAM CHEMICAL CO.
TAMPA STP
Hookers Point
Delaney Creek
Port Sutton
Ballast Point
INTERBAY PENINSULA
Archie Creek
US PHOSPHORIC PRODUCTS CO.
ALAFIA RIVER
MacDILL AIR FORCE BASE
MacDILL STP
Gadsden Point
Bullfrog Creek
TOTAL PHOSPHATE PERCENT BY WEIGHT
▨ 0-1%
▨ 1-2%
▤ 2-3%
▥ MORE THAN 3%

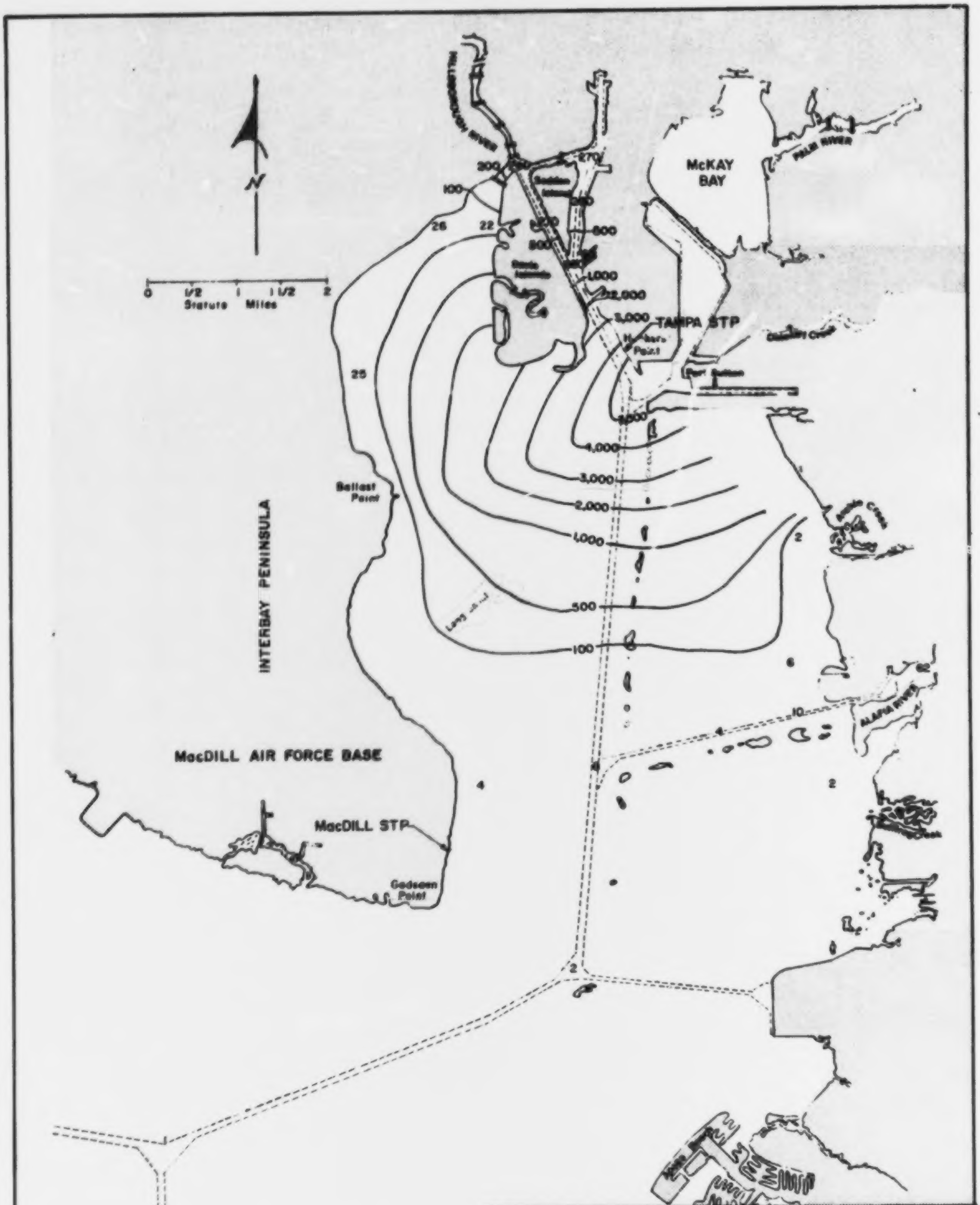
HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

TOTAL PHOSPHATE DISTRIBUTION IN BOTTOM SEDIMENTS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

27-6

FIGURE 9.13


N
0 1/2 1 1 1/2 2
Statute Miles
HILLSBOROUGH RIVER
PALM RIVER
McKAY BAY
270
200
100
26
22
800
600
1,000
2,000
3,000
TAMPA STP
Hookers Point
Port Sutton
5,000
4,000
3,000
2,000
1,000
500
100
25
Ballast Point
INTERBAY PENINSULA
MacDILL AIR FORCE BASE
4
MacDILL STP
Gadsden Point
2
6
10
4
ALAFIA RIVER
2
2

LOG MEAN FECAL COLIFORM PER 100 ml.
WEEKLY SURFACE SAMPLES, JUNE-DECEMBER 1967

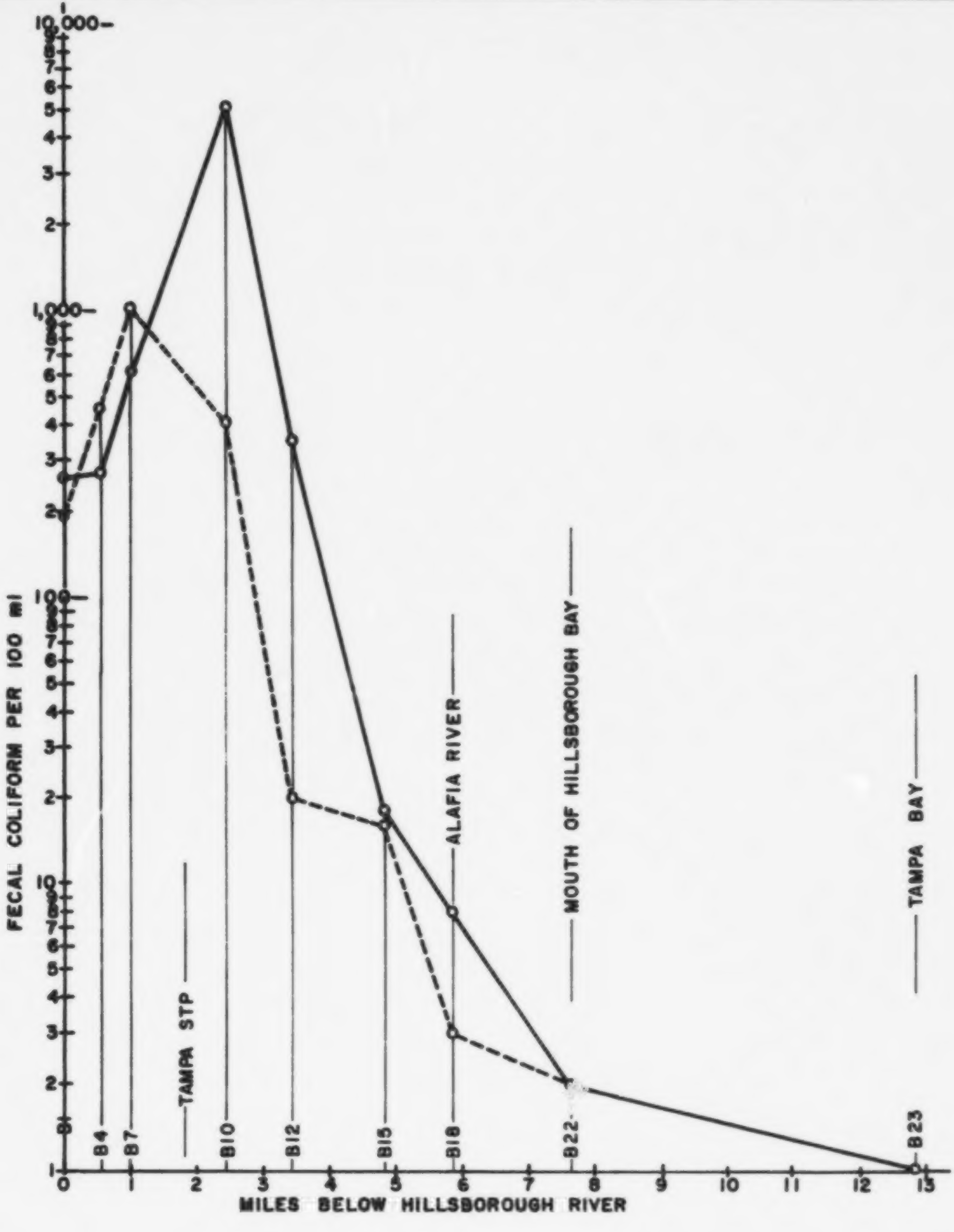
HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

FECAL COLIFORM

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

FIGURE 9.14

27-C



NOTE: LOGARITHMIC MEAN OF WEEKLY DATA JUNE 1967-DEC 1967

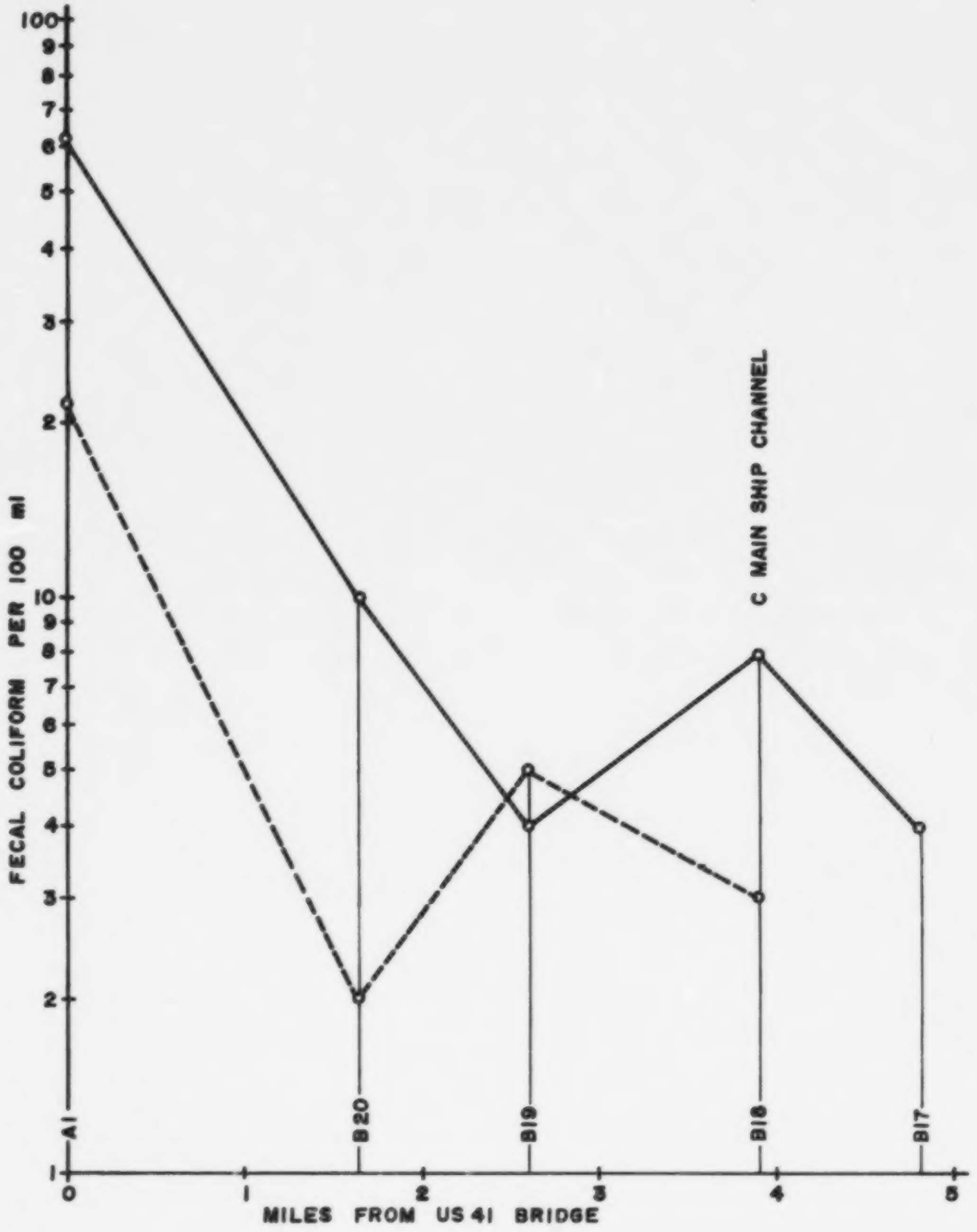
HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

MEAN FECAL COLIFORM
MAIN CHANNEL STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

27-d

FIGURE 9.15



NOTE: LOGARITHMIC MEAN OF WEEKLY DATA— JUNE 1967–DEC 1967

——— TOP - 5 FT.

– – – BOTTOM - 20 FT.

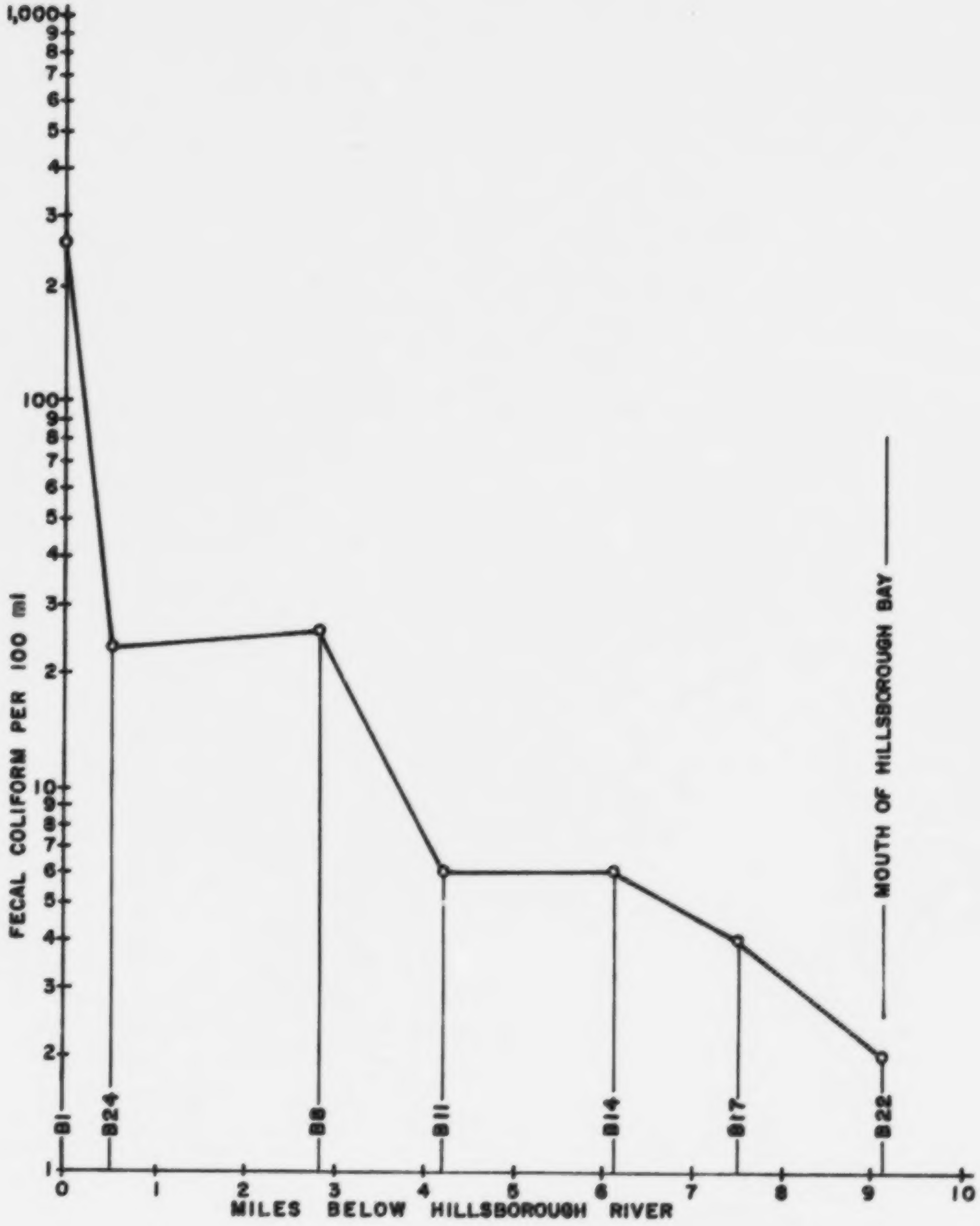
HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

MEAN FECAL COLIFORM
ALAFIA RIVER CHANNEL

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

27-E

FIGURE 9.16



NOTE: LOGARITHMIC MEAN OF WEEKLY
DATA — JUNE 1967 - DEC 1967

HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

MEAN FECAL COLIFORM
WEST SHORE STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

27-F

FIGURE 9.17

10.

BENTHIC ALGAE

The purpose of this section is to provide biological information on the red alga Gracilaria (Rhodophyta, Rhodophyceae) in Hillsborough Bay. In June 1967 a biological study was initiated by this project to study the life history, standing crop, distribution and general ecology of Gracilaria in Hillsborough Bay. Early in this investigation it became evident that decaying Gracilaria was producing the odor along the western shore. Concurrent studies were then undertaken to determine the cause of death and decay of the Gracilaria. These studies included laboratory experiments on the effects of chlorosity, sewage, light and benthic deposits on Gracilaria. An odor panel was initiated to correlate occurrence of odors with death and decay of the Gracilaria. Although this section is primarily concerned with Gracilaria biology, a subsequent section will discuss Gracilaria as it relates to odor production and water quality in the Bay.

Method of Study

To sample Gracilaria, six transects were located perpendicular to the western shore of the Hillsborough Bay (foldout map in rear of report). Table 10.1 describes each transect location. Transects were subdivided with stations at 50 yard intervals. Station one was at the high tide line (or the seawall) and Station two was 50 yards bayward, etc. Each transect ranged in length from 450 to 600 yards and usually extended to or just beyond the 6-foot contour. No vegetation was found beyond the 6-foot contour.

Stakes were driven into the bottom at each station to insure repetitive sampling within a 15-foot radius each month. Three grab samples were taken at each station with a Petersen dredge. The samples were sieved through a one-fourth inch mesh screen and placed in plastic bags for transport to the laboratory. Each grab was processed separately and all foreign material was removed from the washed Gracilaria. Excess moisture was blotted from the algae with a paper towel. Wet weights were determined to the nearest 0.1 gram on a triple beam balance.

Hillsborough Bay Technical
Assistance Project

Table 10.1

BENTHIC ALGAE TRANSECT DESCRIPTIONS
WEST SHORE OF HILLSBOROUGH BAY

Transect	Location
T1	On a line between Edison Avenue and the south tip of Davis Island
T2	Perpendicular to shore between Bay View and Tambay Avenues
T3	Perpendicular to shore and about 600 yards south of Tampa Yacht and Country Club
T4	Perpendicular to shore at the corner of Bayshore Drive and Garden Drive
T5	Perpendicular to shore and about 100 yards north of golf driving range office
T6	On a line extending in a southeasterly direction from the southeastern tip of Gadsden Point

Originally, four beach transects were selected for studies of the algae that were deposited on the beach. However, for the last beach transect study (March 1968) two additional transects were selected, one near the MacDill Air Force Base hospital and the other off the MacDill Air Force Base skeet range. The weight of the beach deposited algae was determined quarterly. Each beach transect was sampled at three foot intervals from the high tide line down to the bayside of the deposit. A sharpened tube that had a $1.6X10^{-3}M^2$ area (1½ inch i.d. pipe) was thrust through the algal deposit well into the sand. The sample was treated the same as the bay grab samples. The area of the beach deposited algae was determined by measuring with a 100 foot tape and a wheel meter.

Light penetration determinations were made by utilizing a G. M. submarine photometer, Model No. 268WA310.* Light intensity readings were made above the water surface, slightly subsurface, and at three and six foot depths. Appropriate calculations were made to determine percent light transmission at these four positions.

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*The use of the name G.M. Manufacturing & Instrument Corporation does not necessarily represent endorsement of this product by the Federal Water Pollution Control Administration.

Taxonomy and Physiology

There are four principal species of algae presently in Hillsborough Bay: Cheatomorpha linum, Ulva lactuca, *Gracilaria verrucosa*, and G. folifera. * The two species of *Gracilaria* make up about 98 percent of the standing crop. Both species undergo morphological alterations with changing environments. This characteristic makes *Gracilaria* particularly difficult to identify in Hillsborough Bay since the chlorides, dissolved gases, temperature, microbiology and density of growth are constantly changing. During the summer of 1967 both species of *Gracilaria* were present; later in the fall and winter only G. foliifera was present and in 1968 G. foliifera was almost the exclusive species in the Bay. Since it is difficult to distinguish between these species due to their changing morphology, for this study they are all treated simply as *Gracilaria*.

In Hillsborough Bay, *Gracilaria* is normally green and bushy, forming clumps about six inches in diameter. Environmental stresses of low chlorosity, low dissolved oxygen, toxic hydrogen sulfide, or extreme crop density produces a rapid morphological change which alters the *Gracilaria* to a red stringy form. In California both *G. verrucosa* and *G. folifera* undergo changes into the red stringy form under environmental stresses (Dawes, Clinton J., personal communication). The red stringy type has never been found in Hillsborough Bay when the environment was not under a stress of low salinity, low dissolved oxygen, or hydrogen sulfide conditions.

Reproduction and Growth

In North Carolina and Great Britain, there are two distinct forms of *G. verrucosa*; an attached sexually reproducing form and an unattached sterile vegetatively growing form.(14) In Great Britain these forms are closely related in that the period of active sexual reproduction coincides with the period of maximum vegetative growth.(15)

*Acknowledgement and appreciation for algae identification are made to Drs. H. J. Humm, Univ. of South Fla., G. W. Prescott, Michigan State Univ., W. R. Taylor, Univ. of Michigan, and C. J. Dawes, Univ. of South Fla.

In Hillsborough Bay, an estimated 0.03 percent of the substrate will support attached *Gracilaria*. This area is about six acres near Ballast Point that has scattered limestone boulders. During the present study, very little attached *Gracilaria* was seen in this area. No studies were made to determine the sexual development of the *Gracilaria* in Hillsborough Bay; however, based on the situation in Great Britain and North Carolina, and the fact that there is little suitable substrate, it is assumed that most reproduction of *Gracilaria* in Hillsborough Bay is by vegetative growth.

During periods of low standing crop in 1967 almost all of the algae was attached to worm tubes of the marine annelid *Diopatra*. Method of attachment appears accidental with the worm incorporating into its tube structure any *Gracilaria* branch that is available. In 1968 about 70 percent of the algae was similarly attached to worm tubes and about 30 percent was incorporated into the matrix of byssus of the "paper mussel" *Amygdalum papyria*. The attached algae, a branch fragment, or a bushy plant continues to grow in this condition until physically removed from the worm tube by wave action. As plants grow larger, they tend to break loose and become free floating on the bottom. During periods of high standing crop, most of the *Gracilaria* is free floating near the bottom. While some of the succeeding year crop develops through vegetative growth of free floating clumps, most of the crop is perpetuated through vegetative growth of the fragments or clumps two to five inches across that are attached to worm tubes.

Although no studies were conducted primarily to determine the exact growth rates of the *Gracilaria*, estimates of the overall net growth of the 1862 acre study area can be made. For this discussion, the monthly variations in total standing crop (Figure 10.1) have been analyzed to give the weight change per day during this study period. This method yields a conservative estimate of growth for any particular area (or crop of *Gracilaria*) since conditions are less favorable for growth in certain areas of the Bay. For example, on an annual cycle, conditions of light and salinity are more favorable for growth at Transect 5 (foldout map) than at Transect 1. These growth values show a rate varying from 0.003 to 2.5 percent

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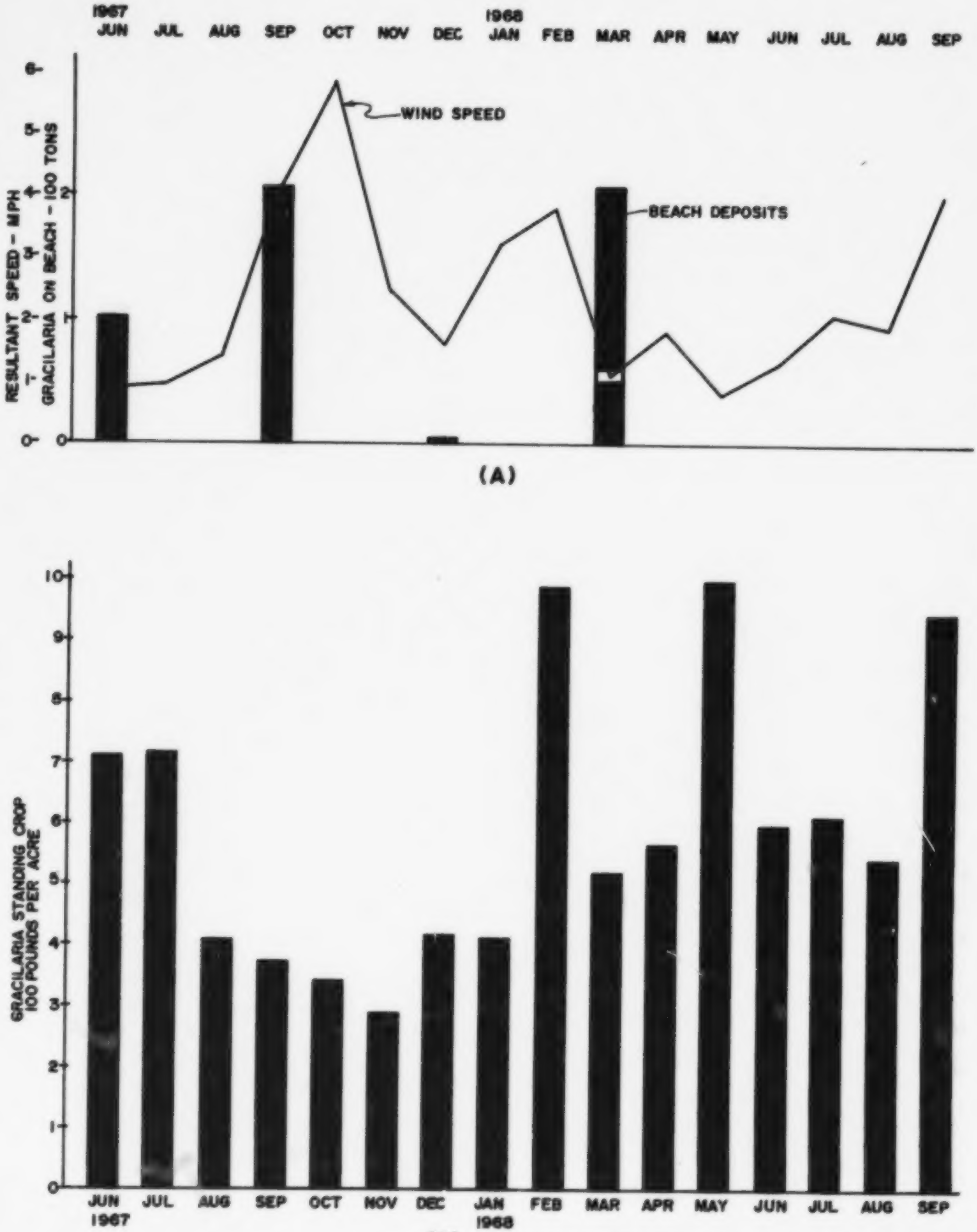
(14) Jones, W. Eifion. 1959. "The Growth and Fruiting of *Gracilaria verrucosa* (Hudson) Papenfuss." J. Mar. Biol. Ass. U.K. 38:47-56 and Causey, Nelle B., John P. Prytherch, Jean McCaskill, Harold J. Humm, and Frederick A. Wold. 1946. "Influence of Environmental Factors upon the Growth of *Gracilaria confervoides*." Duke Univ. Marine Sta. Bull. 3:19-24.

(15) Jones, *op. cit.*



HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

GRACILARIA STANDING CROP, BEACH DEPOSITS
AND WIND SPEEDS ON WESTERN SHORE

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

29-a

FIGURE 10.1

per day. Assuming simultaneous death and growth, these values would then indicate the net growth for the 1862 acres along the west shore of Hillsborough Bay. Jones found that G. verrucosa in Great Britain grew from 1.0 to 2.6 percent per day and Kim and Humm[16] showed that G. folifera in Alligator Harbor, Florida grew at the rate of 2.2 to 3.7 percent per day. Laboratory experiments with Gracilaria on this project yielded growth rates of 0.2 to 2.0 percent per day under varying conditions of salinity, light and types of experimental containers.

Distribution

In most Florida bays, the majority of benthic plants are found above the 6-foot water depth contour (MLW). In Hillsborough Bay, the Gracilaria is within this zone and most abundant growths are in 3½ feet of water or less. Benthic algae in a shallow bay such as Hillsborough Bay is more affected by wind driven tides and waves than algae in a deep bay. Winds move algae from one area to another along the western shore and deposit large amounts of the algae onto the beach. Profiles of the bay bottom along with the relative abundance of Gracilaria at each 50-yard interval along this transect are shown in Figure 10.2.

Cumulative results at all transects indicate the higher crops inshore decline gradually into deeper water. The area from the shore to the 3½ foot isopleth accounts for 84 percent of the total weight. Seventy-five percent of the algae is found in a band from 50 to 250 yards offshore and 88 percent is found from 50 to 350 yards offshore. Gracilaria accumulates in dredged channels or depressions. A storm in February 1968 accumulated much of the crop into a windrow in two feet of water about 250 yards offshore. This distribution persisted through September 1968.

The distribution of the average monthly standing crops in areas 1 through 6 (Figure 10.3) by percentage is given below:

Area	Transect	Acreage	Percent of mean monthly standing crop
1	T1	360	6
2	T2	390	15
3	T3	96	6
4	T4	425	24
5	T5	300	39
6	T6	380	10

The above table indicates that area 5 (Transect T5) has the highest average standing crop (39 percent) in this study zone.

Results of 85 light penetration measurements indicated that water turbidity decreases toward the mouth of the bay. The following table shows mean yearly light values for each bay station nearest the listed transect:

Station	Transect	1 Percent Light Level
B24	T1	5'2"
B8	T2	6'11"
B11	T3	6'2"
B14	T4	8'7"
B17	T5	8'2"

In general there is an increase in light penetration from north to south in the Bay. The algal crop also increased on a north-south gradient as shown by the percentage values above. Kim and Humm[17] and others[18] found a direct correlation with increased light and growth of G. foliifera and G. verrucosa. The standing crop is maintained at a higher level farther offshore in the southerly transects (T4,T5,T6) because of the greater light penetration (Figure 10.2).

To determine if Gracilaria were present in deeper areas of the Bay, a 16-foot wide otter trawl was towed on 20 stations in April and May 1968. Most of the trawl runs were of fifteen minute duration. No Gracilaria was found on any station where the water was deeper than six feet; therefore, it is unlikely that "across the bay" migrations of Gracilaria occur.

Standing Crop

Standing crop is defined as the biomass of Gracilaria at a specific time. For this discussion, the area of study includes only transects and stations along the western shore of Hillsborough Bay (Figure 10.3). All mass values of standing crop reported are wet weight.

The standing crop within the bay was determined monthly at six transects and the amount deposited on the beach was measured quarterly. These two crops are evaluated separately (Figure 10.1, Section A and Section B). A seawall exists from one mile north of T1 to 0.7 miles south of T2. From the southern end of the seawall on southward, Gracilaria is deposited on the five miles of beach.

[16] Kim, Chum Su and H. J. Humm. 1965. "The Red Alga, Gracilaria foliifera, With Special Reference to the Cell Wall Polysaccharides." Bull. Mar. Sci. 15(4):1036-1050.
[17] Ibid.
[18] Jones and Causey, op. cit.

Standing crop studies were begun in June 1967 at which time Gracilaria was decaying in areas 1 and 2. The crop was 714 and 716 pounds/acre in June and July 1967 respectively (Figure 10.3). A significant crop decline occurred from July to August at which time freshwater discharge down the Hillsborough River was at its annual peak (Table A.2). Chloride concentrations in g/l were down to 3.9 at station B24, 5.1 at B8 and 5.5 at B11 in August 1967. The resulting lower chlorosity was responsible for the death of the algae. The crop continued to decrease through November even though chlorosity had returned to a sublethal level. As shown on Figure 10.1, Section A, monthly mean wind speeds were increasing and through wave and tidal action deposited algae onto the beach. After November, the standing crop began an increasing trend through May 1968. The extraordinary high mass record for February was caused by a storm windrowing most of the algae crop in about two feet of water parallel to shore. Much of this algae was later deposited onto the beach (Figure 10.1, Section A). As a consequence, the crop was reduced 47 percent from February to March. The crop increased slightly from March to April but from April to May a 79 percent increase occurred. Large yearly increases during the April to May period have been observed by other investigators in Great Britain(19) and Florida.(20) There was a substantial decrease in standing crop from May to June. At this time the rainy season had begun (Figure 6.3) and there were influxes of storm drainage water into the Bay which was killing the algae. The decline in the standing crop continued until August and then growth was resumed in September.

Summary

In summary, the findings of this study indicate that:

1. Of the four principal species of algae presently in Hillsborough Bay, Cheatomorpha linum, Ulva lactuca, Gracilaria verrucosa, and G. foliifera, the two species of Gracilaria make up 98 percent of the standing crop.

2. Eighty-four percent of the standing crop occurs in 3½ feet of water or less. Seventy-five percent of the algae is found in a band 50 to 250 yards off the western shore, and 88 percent is found 50 to 350 yards offshore.

3. Practically all of the Gracilaria in Hillsborough Bay is unattached and free floating on the bottom where it reproduces by vegetative growth.

4. On a weight basis, growth rates of the algae in the Bay range from 0.003 to 2.5 percent per day.

5. Inflows of freshwater will kill Gracilaria.

6. Strong winds cause algae to be deposited onto the beach.

7. Standing crop reaches a maximum between May and July.

Comparison of Aquatic Plants in Old Tampa Bay and Hillsborough Bay, June 1968

Although Old Tampa Bay and Hillsborough Bay are part of the complex of Bays called Tampa Bay, their geomorphology causes partial isolation and allows development of separate water qualities. Both bays are similar in physical characteristics. Chlorophyll a values for Hillsborough Bay are five times greater than Old Tampa Bay. This indicates Hillsborough Bay has a higher phytoplankton biomass which is supported by higher nutrient levels. Water clarity is greater in Old Tampa Bay allowing greater light penetration to the aquatics.

There are four species of benthic algae in Hillsborough Bay and almost no rooted vegetation, although Old Tampa Bay has 12 abundant species of both algae and rooted aquatics.

Standing crops of the benthic plants were determined in both bays during June 1968. Eleven transects perpendicular to shore, with stations at 50-yard intervals, were selected for Petersen dredge sampling in Hillsborough Bay. Twenty-one transects were used in Old Tampa Bay (see Figure 10.4). Transects were at approximately 1½ mile intervals along the shore and extended to the six foot contour when possible. Three grab samples were made at each station.

The mean standing crop in Hillsborough Bay was 512 pounds/acre compared to 532 in Old Tampa Bay. These values, along with numbers of species in each bay, indicate that higher levels of enrichment have the effect of decreasing benthic plant diversity rather than increasing standing crop. The tendency is to change from a rooted aquatic system to free floating algae. Chlorophyll a values from above the Courtney Campbell Causeway in Old Tampa Bay are 14.24 mg/l while they are 10.57 below the causeway. Percentage occurrence of algae in Old Tampa Bay

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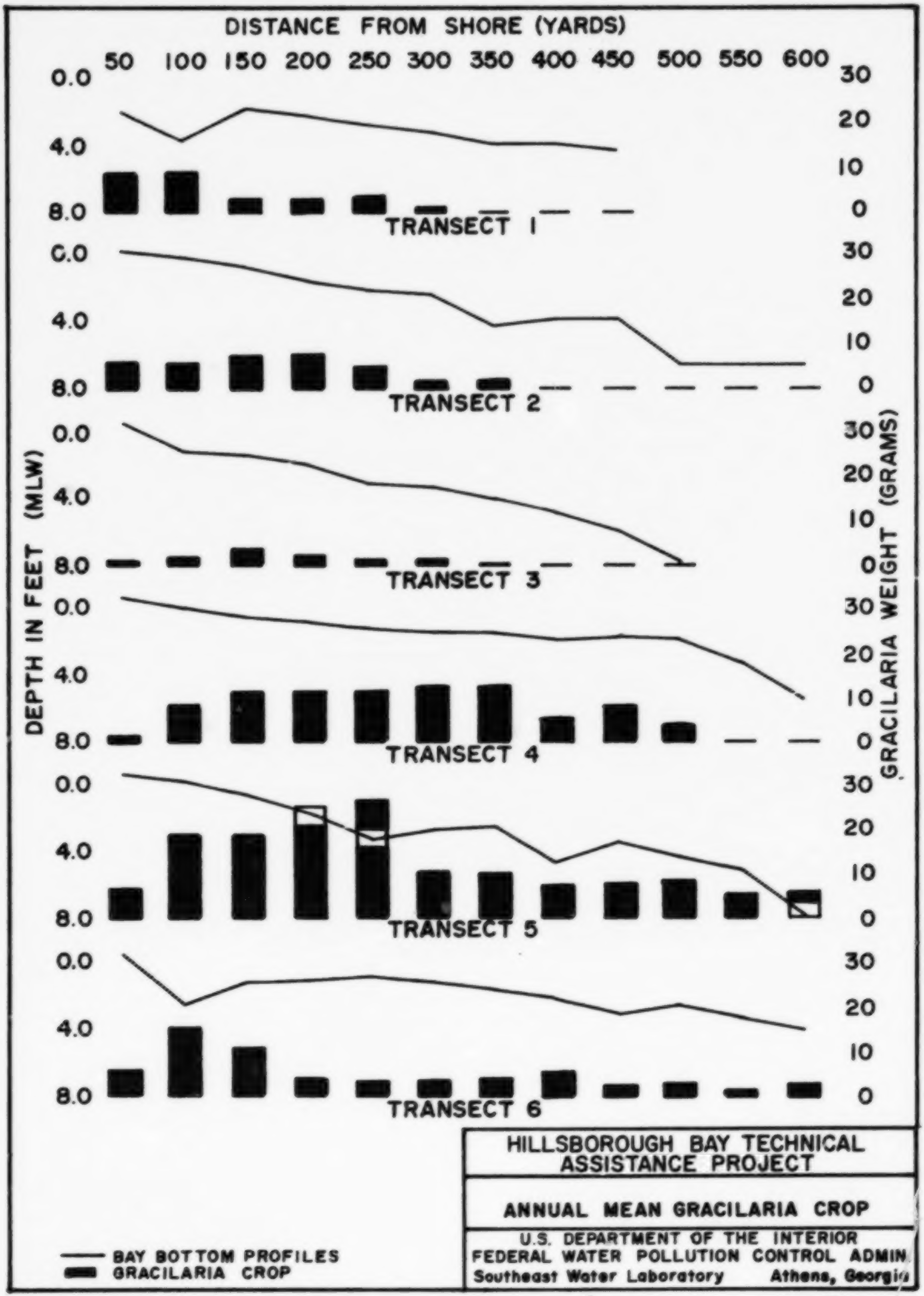
(19)Jones, op. cit.
(20)Causey, op. cit.



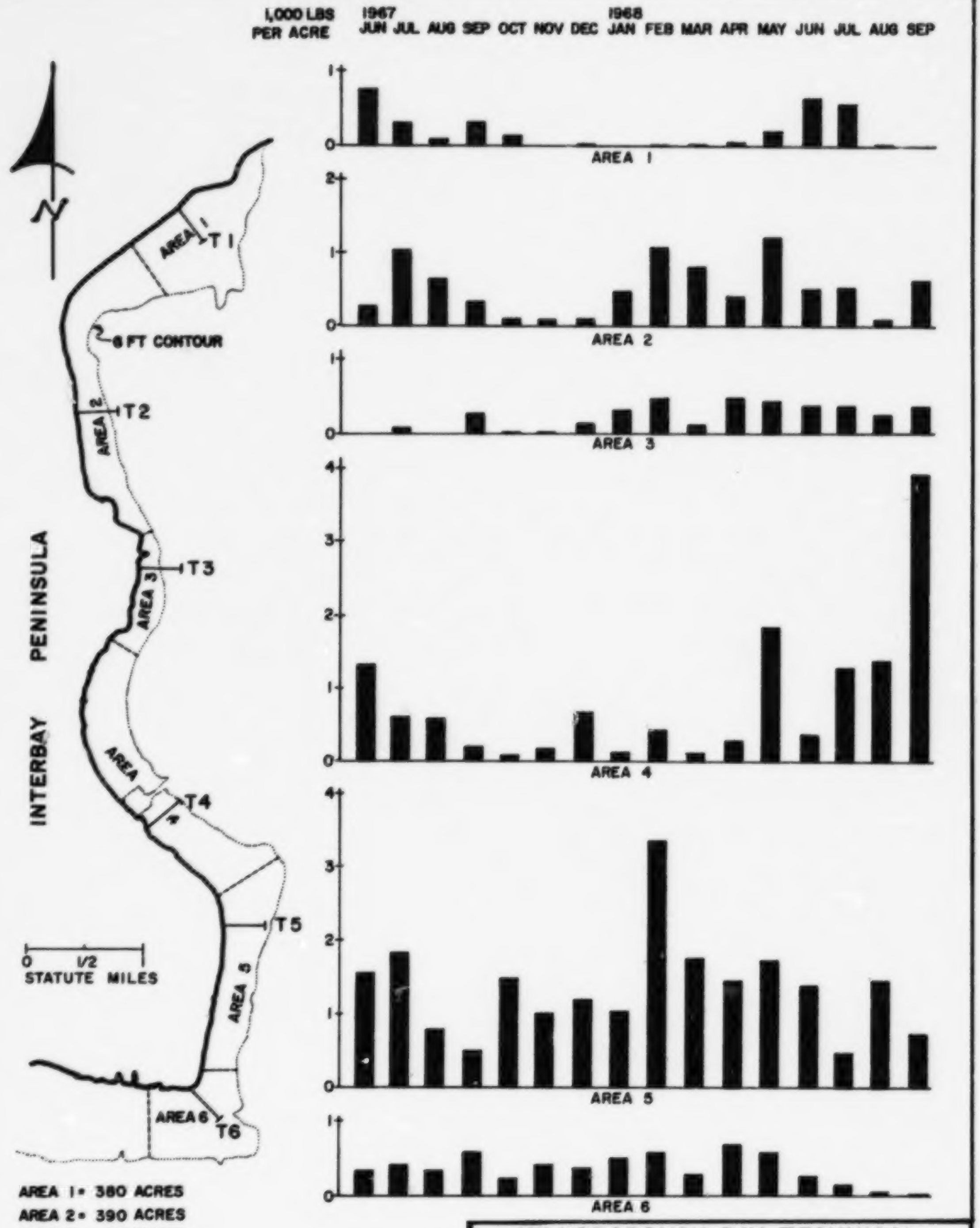
HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

ANNUAL MEAN GRACILARIA CROP

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

31-b

FIGURE 10.2



AREA 1 = 380 ACRES
AREA 2 = 390 ACRES
AREA 3 = 96 ACRES
AREA 4 = 425 ACRES
AREA 5 = 300 ACRES
AREA 6 = 280 ACRES

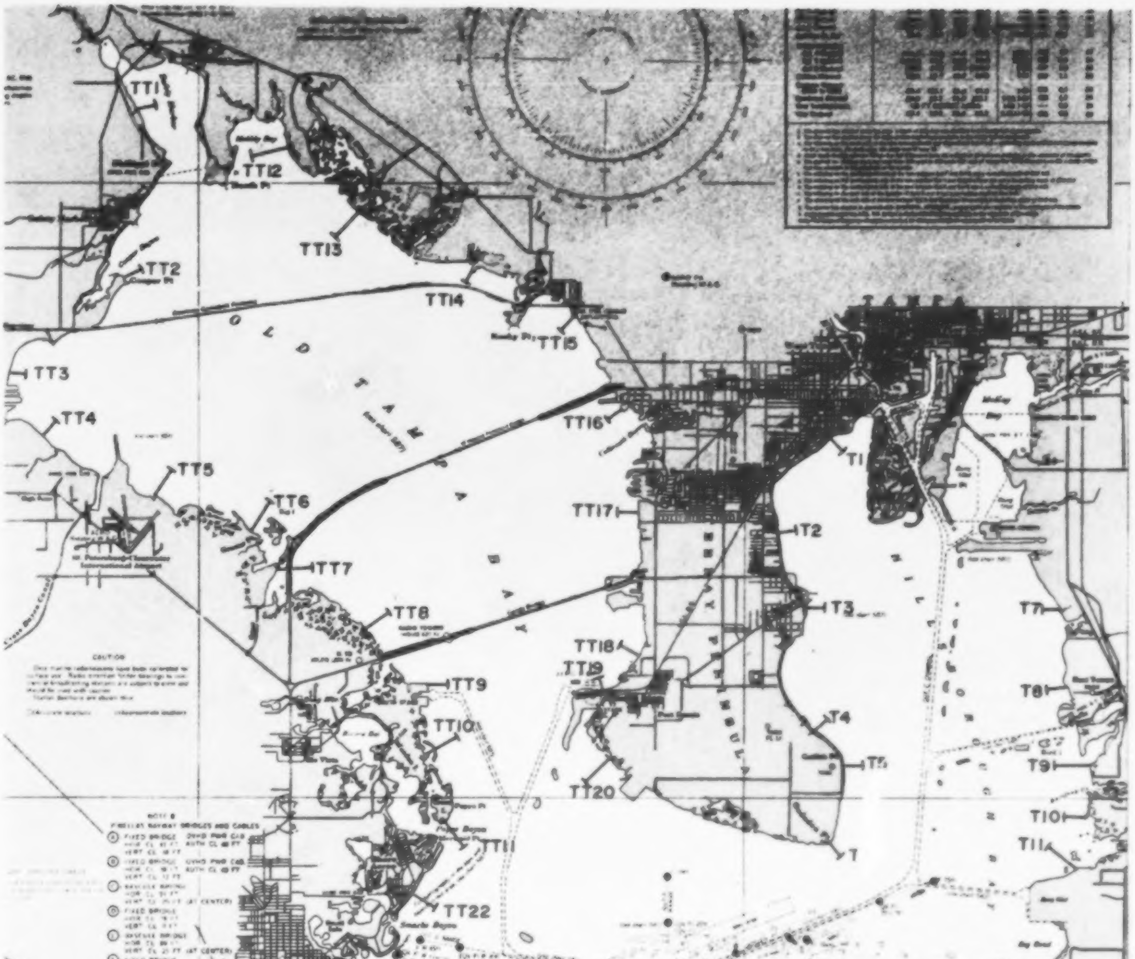
HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

GRACILARIA STANDING CROP

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

31-f

FIGURE 10.3


TT1
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TT2
TT14
TT15
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TT8
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TT11
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TT17
TT18
TT19
TT20
T1
T2
T3
T4
T5
T7
T8
T9
T10
T11
TAMPA
OLD TAMPA BAY
ST. PETERSBURG

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

BENTHIC ALGAE TRANSECTS

U.S. DEPARTMENT OF THE INTERIOR
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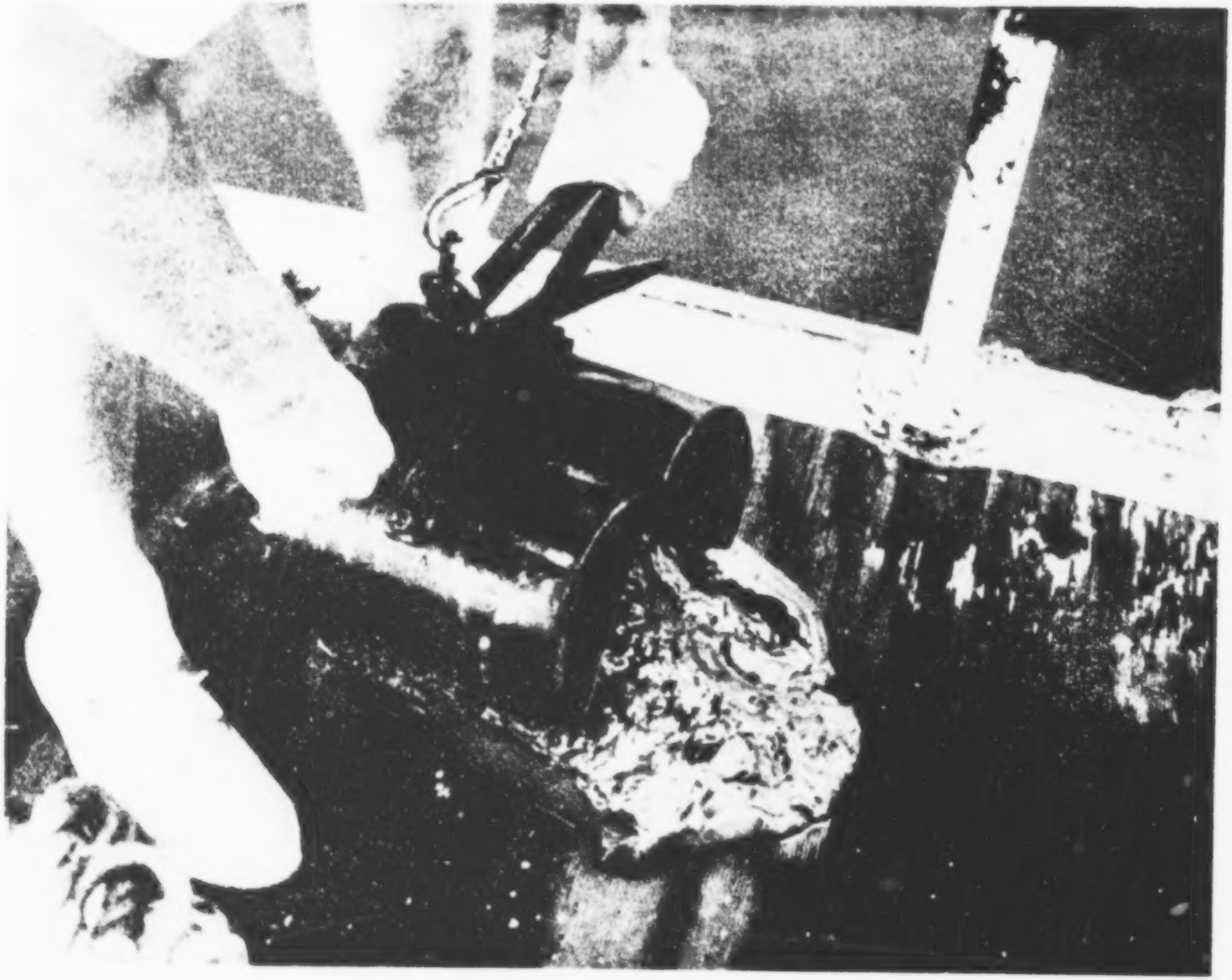
FIGURE 10.4

3-C

P-15



Mud from bottom of main ship channel near southern tip of Seddon Island

Hillsborough Bay Technical
Assistance Project

Table 10.2

OLD TAMPA BAY TRANSECTS - NORTH TO SOUTH
JUNE 1968

Percent Occurrence - Eastern Shore

Station	Gracilaria	Other Algae	Ulva	Rooted Vegetation
TT1*	0	32	0	68
TT2*	1	39	0	61
TT3	7	31	14	49
TT4	0	6	7	86
TT5	2	31	0	67
TT6	0	8	0	92
TT7	9	24	0	67
TT8	0.2	11	0.2	88
TT9	1	2	0	97
TT10	0	4	5	91
TT11	4	12	18	66
TT22	0	0	0	100
TT21	1	0	0	99

Percent Occurrence - Western Shore

Station	Gracilaria	Other Algae	Ulva	Rooted Vegetation
TT12*	1	48	0	52
TT13*	9	47	0	44
TT14*	3	43	0	54
TT15	0	33	0	67
TT16	--	----	--	----
TT17	0	0	0	100
TT18	0	9	0	91
TT19	0	0	0	100
TT20	0	0	4	96

*Above Courtney Campbell Causeway.

shows a grading from more algae above the causeway to less below (Table 10.2). Rooted aquatics follow an inverse pattern. Plant succession in upper Old Tampa Bay would likely be toward fewer species of rooted aquatics and fewer species of algae as the water quality degraded. As water quality degrades, the standing crop of phytoplankton usually increases and the benthic algae changes to species that are more tolerant to lowered light concentrations. Apparently Gracilaria is tolerant to lowered light concentrations and degraded water quality.

In Hillsborough Bay Gracilaria makes up 98 percent of the crop while in Old Tampa Bay it is only 2 percent. Percentages of the four groups in Old Tampa Bay are: 2 percent Gracilaria, 2 percent Ulva, 18 percent other algae, and 78 percent rooted aquatics. This is an example of a diversified plant ecosystem which is conducive to sustaining aquatic organisms. Hillsborough Bay on the other hand has a reduced benthic plant ecosystem and does not support a diversified population of plants.

11.

ODOR PRODUCTION

Field observations indicated that there were at least two distinct odors; one a nauseating, vegetative odor occurring predominantly at MacDill Air Force Base, and the other a cutting hydrogen sulfide odor occurring predominantly along the seawall of Bayshore Boulevard. Early in the study it was evident that dacaying Gracilaria, a benthic alga, was responsible for the odors. It was hypothesized that the rotten vegetative odor is a result of Gracilaria decaying in windrows on shore and the hydrogen sulfide odor is a result of Gracilaria decaying under anaerobic conditions in the water. Several studies were initiated to determine the mechanism by which the odors are produced.

Water Quality in Odor Area

Chlorides, dissolved oxygen and total sulfide concentrations were determined at 16 stations on eight transects along Bayshore Boulevard. Data were collected once a week from February 26, 1968 until mid July at which time the sampling frequency was increased to either two or three times per week until August 26, 1968. Table 11.1 is a summary of the data stating the chloride range, date of the first zero dissolved oxygen and the date of the first sulfide detected. Two stations were located on each of the eight transects, one at a distance of 25 yards from shore and the other at 200 yards from shore; thus, the number appearing after the transect number is the distance in yards from the shore at high tide line.

The chlorosity along the eight transects was about 15.5 g/l Cl^- from the start of the collection of data (February 26, 1968) until early June, 1968 at which time the chlorosity started to decrease. The chlorosity dropped below 6.0 g/l Cl^- at five of the eight transects during July (T1, T2, T3, T7, T8). The dissolved oxygen was depleted and sulfides were detected at three of these five transects (T1, T2, T7). At transect, T3, the standing crop of Gracilaria was very low (Figure 10.3) and no odors were detected. At transect, T8, no standing crop data are available and it is assumed that the quantity of Gracilaria killed or put under stress was insufficient to deplete the dissolved oxygen.

Where the chlorosity did not fall below 6.0 g/l (T4, T5, T6), Gracilaria was not killed, dissolved oxygen was not depleted, and no sulfides were detected, even though the standing crop at T4 and T5 was large (Figure 10.3).

Mechanisms of Odor Production

A series of preliminary jar tests were conducted in the laboratory to verify field findings. A series of 18 duplicate one-gallon wide mouth jars filled with Bay water and various amounts of Gracilaria, sewage, and benthic sludge and combinations thereof were observed for 18 days.

Four general conclusions reached from the jar tests were:

1. Sludge alone produced sulfides and odor.
2. Sludge with Gracilaria produced more sulfides than sludge alone.
3. Sewage deoxygenated the water, but did not produce measurable sulfides.
4. Although the branches died back and the alga appeared weakened, it was not completely killed by prolonged exposure to sulfides in concentrations up to 20 mg/l.

Based on these preliminary results, more sophisticated laboratory tests, which will be referred to as enclosed system tests, were conducted. Again healthy Gracilaria, sewage, and benthic material, and combinations thereof, were investigated. The findings were essentially the same as in the jar tests. Healthy, growing Gracilaria produced neither sulfides nor odors, but continued to increase in biomass and produced supersaturated dissolved oxygen. Sewage and benthic sludge at test concentrations killed the Gracilaria and produced 13 to 16 times more sulfide than was produced with sewage or sludge alone. This shows that odors result from the decay of Gracilaria and not simply from its presence. Since field measurements and observations indicated that Gracilaria might be sensitive to reduced chlorosity, a second series of enclosed tests were conducted to determine the tolerance of this algae to various levels of chlorosity which were encountered in the Bay. This test series was composed of six systems containing healthy Gracilaria with chlorosity concentrations ranging from 4.0 to 14.0 g/l.

The findings from this series were:

1. The systems containing 4.0 and 6.2 g/l of chlorides caused the death and decay of Gracilaria and produced sulfides and odors.

Hillsborough Bay Technical
Assistance Project

CHLOROSITY AND WATER QUALITY ALONG THE WESTERN SHORE OF HILLSBOROUGH BAY

Table 11.1

Summary of Western Shore Water Quality Data
February - August 1968

Station	Range of Chloride g/1	First Zero Dissolved Oxygen	First Sulfide
T1-25	3.9 - 15.6	7/17	7/17
T1-200	5.1 - 15.7	7/17	7/17
T2-25	3.9 - 15.8	6/12	6/12
T2-200	4.3 - 16.3	None	None
T3-25	5.5 - 16.4	None	None
T3-200	5.7 - 16.1	None	None
T4-25	6.2 - 16.3	None	None
T4-200	6.6 - 16.2	None	None
T5-25	6.4 - 16.2	None	None
T5-200	6.7 - 16.4	None	None
T6-25	6.8 - 16.7	None	None
T6-200	7.1 - 17.8	None	None
T7-25	4.9 - 15.9	7/17	7/17
T7-200	4.8 - 15.9	7/17	7/29
T8-25	4.4 - 16.2	None	None
T8-200	4.8 - 16.1	None	None
B3T	4.7 - 15.9	7/29	None
B3E	8.0 - 15.9	7/17	7/17

2. The *Gracilaria* remained healthy and no sulfides were produced at a chlorosity of 8.2 g/l in the laboratory enclosed system and the biomass increased 23 percent during the 32 days.

3. The dissolved oxygen was depleted in the two systems of lowest chlorosity (4.0 and 6.2 g/l Cl^-) by the third and 11th day respectively. The production of total sulfides was simultaneous with the depletion of dissolved oxygen in the 6.2 g/l Cl^- test while there was a lag of three days in production of sulfide in the 4.0 g/l Cl^- system.

4. The rate of total sulfide production in the two systems containing decaying *Gracilaria* was almost identical once both systems were acclimatized to septicity. The rates in the 4.0 and 6.2 g/l Cl^- tests from the 16th day to the 32nd day were 8.0 and 7.0 mg/l $S^=$/day respectively and the total sulfide concentrations at the end of the experiment were 172 and 130 mg/l $S^=$ respectively.

5. The biomass of *Gracilaria* in the tests of 8.2, 9.8, 12.3, and 14.0 g/l Cl^- increased 23, 20, 23, and 12 percent respectively during the 32 day test period.

A final series of tests was investigated to determine the effect of sewage on the survival of *Gracilaria* in the laboratory enclosed systems under reduced chlorosity environments. This was investigated on the premise that sewage might kill *Gracilaria* very quickly if the alga were already under stress of reduced chlorosity. No significant differences in the mortality rate of *Gracilaria* were observed when it was subjected to sewage of B.O.D. concentrations which would be found in the odor area.

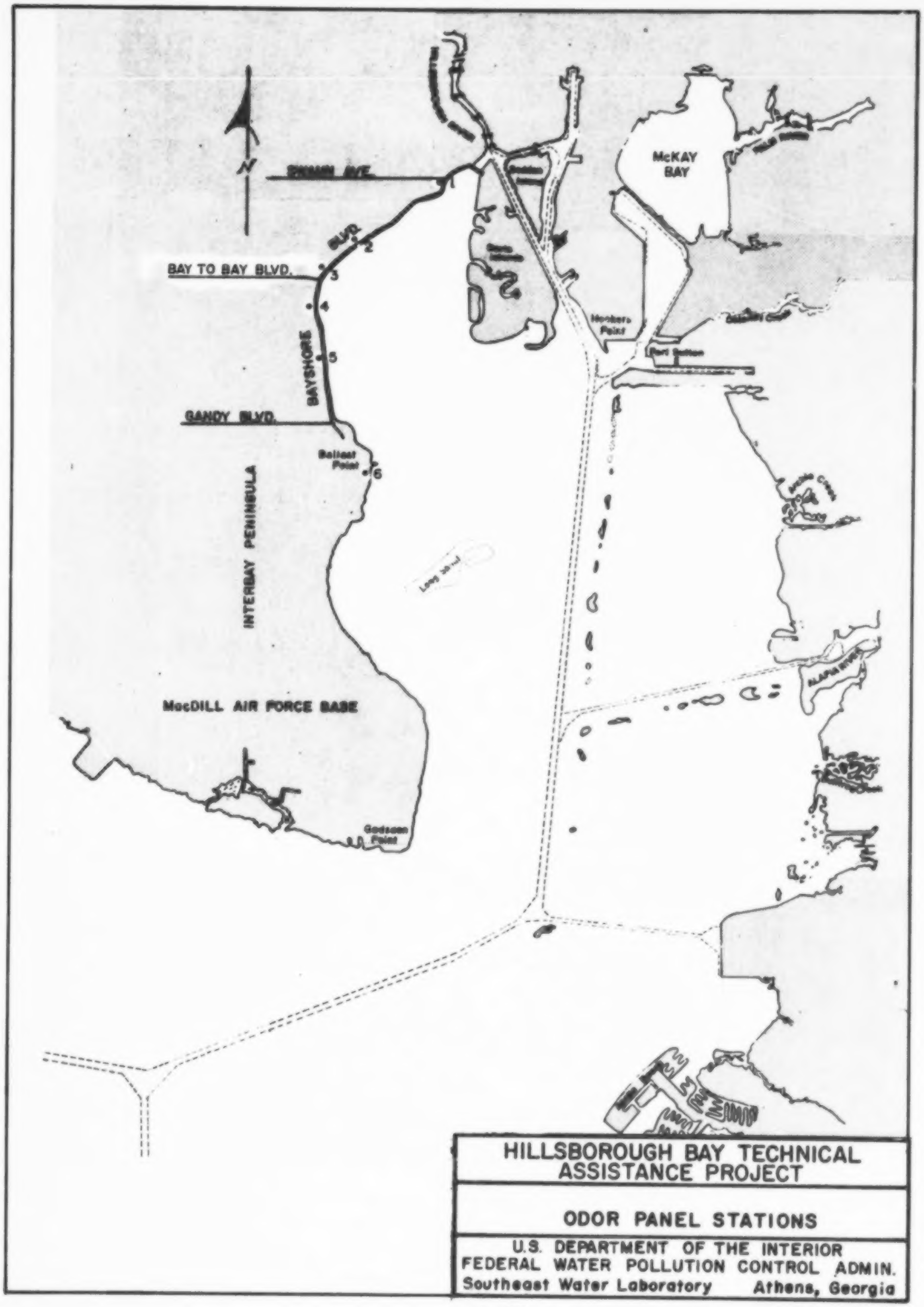
In summary, the water quality data along with the laboratory tests demonstrated that: 1) healthy *Gracilaria* does not produce odors, 2) reduction of chlorosity to 6.0 g/l kills *Gracilaria* and produces odors, and 3) the presence of sewage combined with reduced chlorosity did not aggravate odor production.

Odor Surveillance Panel

In order to test the response of the public to the occurrence of obnoxious odors and to provide the Project with information concerning the occurrence, frequency, and severity of odors, an odor surveillance panel was established. Ten observers at six locations along Bayshore Boulevard were recruited (Figure 11.1). Surveillance was maintained from June 1967 through January 1968 and from April 1968 through August 1968.

To quantify these data, an odor index was defined as the odor intensity times the days over which the odor occurred summed over the particular period under investigation. This odor index was distributed spatially and temporally and odors correlated with loss in standing crop of the benthic algae *Gracilaria*. Spatial distributions of the odor index indicate that in 1967 the most intense odor occurred along Bayshore Boulevard south of Bay to Bay Boulevard while in 1968 odors were uniformly distributed along Bayshore Boulevard south of Barcelona Avenue (Figure 11.2). Temporal distribution of the odor index shows that the most intense odor occurs during the summer months of July and August, and that the occurrence of odor can be correlated with loss of standing crop of *Gracilaria* (Figure 11.3).

In summary, it has been demonstrated with field data and confirmed with laboratory tests that: 1) hydrogen sulfide and odors are produced when *Gracilaria* decays under anaerobic conditions, 2) chlorosity of 6.0 g/l or less will kill *Gracilaria*, 3) *Gracilaria* did not die when chlorosity remained above 6.0 g/l, and 4) the presence of sewage combined with reduced chlorosity did not aggravate odor production.


N
SWANN AVE.
BAY TO BAY BLVD.
BAYSHORE BLVD.
GANDY BLVD.
1
2
3
4
5
6
Ballast Point
INTERBAY PENINSULA
MacDILL AIR FORCE BASE
Gadsden Point
McKAY BAY
Hookers Point
Port Sutton
Long Shoal

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

ODOR PANEL STATIONS

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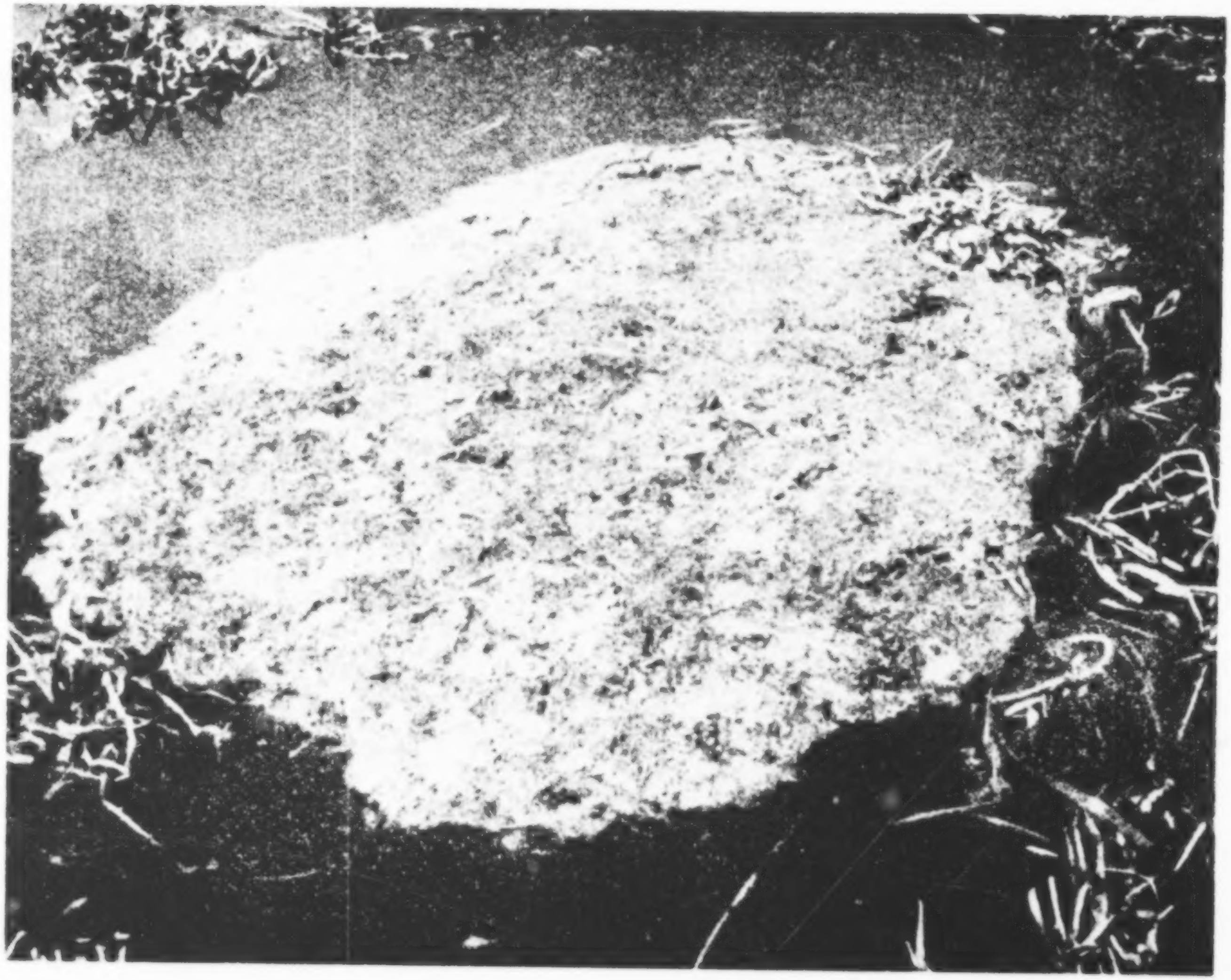
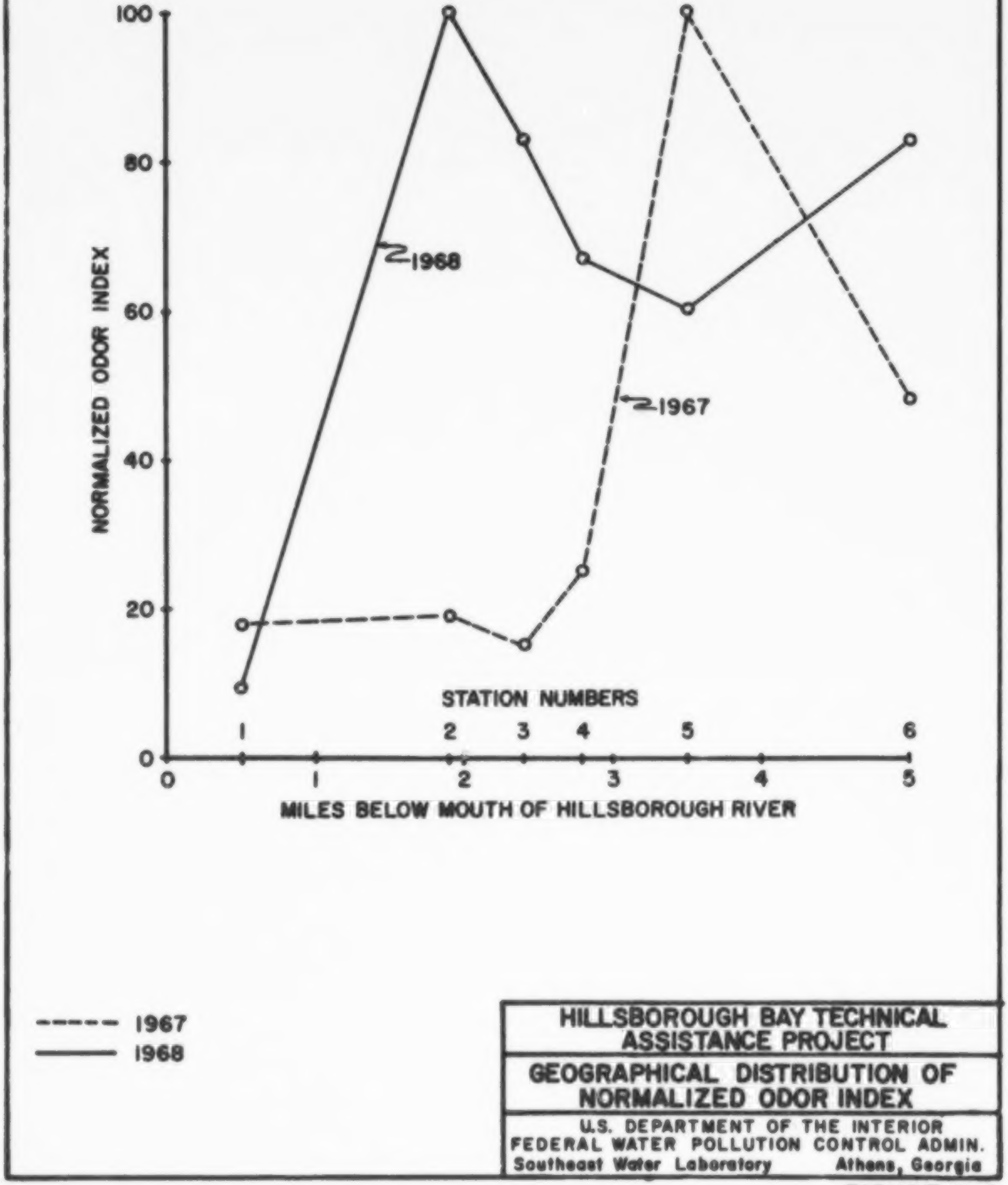
FIGURE II.1



Floating mat of decaying Gracilaria



HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

GEOGRAPHICAL DISTRIBUTION OF NORMALIZED ODOR INDEX

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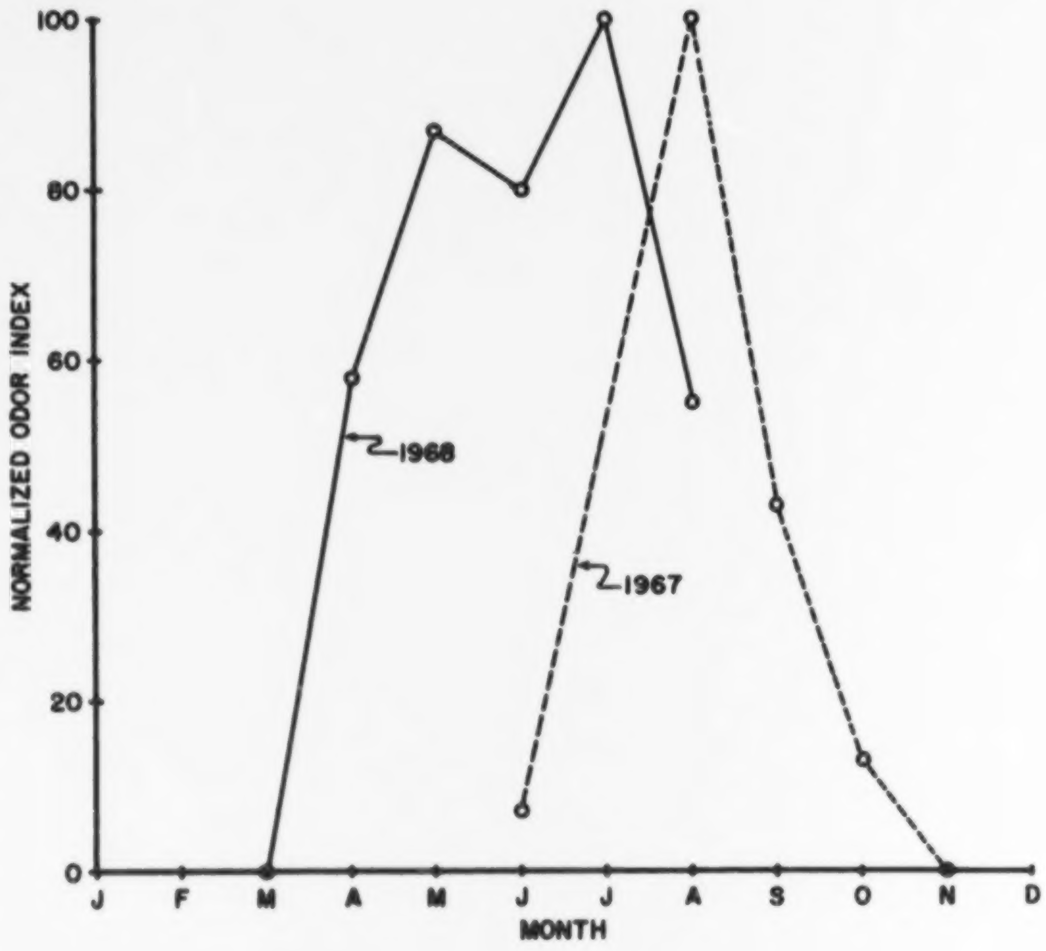
Southeast Water Laboratory Athens, Georgia

FIGURE II.2



HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

MONTHLY DISTRIBUTION OF NORMALIZED ODOR INDEX

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FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

37-d

FIGURE 11.3

Water hyacinths and Gracilaria clog Bayshore.

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12.

SYSTEM SIMULATION

Since field and laboratory studies had confirmed the fact that freshwater diverted along the western shore during high runoff periods was causing death and decay of the excessive growths of Gracilaria, a quantitative evaluation of the input and distribution of freshwater in Hillsborough Bay was necessary to consider the effects of alternative methods of modifying conditions in the Bay to eliminate causes of obnoxious odors (Project's third objective). Of particular importance was the evaluation of the changes in freshwater discharge proposed by the Four Rivers Project of the Southwest Florida Water Management District and the U. S. Army Corps of Engineers. This project, among other things, proposes the diversion of freshwater from the Hillsborough River basin to the Palm River and Six Mile Creek basin. A mathematical simulation of the Bay system has been constructed and verified with respect to the chloride concentrations in the Bay. Since chloride concentrations are inversely proportional to the amount of freshwater present, this permits determination of methods to maintain chlorides greater than 6 g/l along the western shore at all times.

Basically, the approach used is an expansion of mathematical simulations that have proved successful in reproducing water quality conditions in the Delaware and Potomac Rivers.(21)(22) Hillsborough Bay is divided into 40 segments and a material balance is constructed for each segment. A series of simultaneous equations describing the pollution distribution in each segment can be constructed and solved by matrix inversion using a digital computer. Since the segments are interdependent due to the boundary limitations, the effect on all other segments from changing conditions in one segment can be evaluated. The particular simulation for Hillsborough Bay attempts to describe the lateral as well as the longitudinal distribution of material. Previous applications of this procedure have been limited to the one-dimensional longitudinal distribution.

The hypothesis for developing this mathematical simulation is that water quality (in terms of chlorides, B.O.D., nitrogen or dissolved oxygen) is a function of dispersion, advection, decay and reaeration, and that these relationships can be expressed quantitatively through well established theories of biochemical reactions and turbulent mixing. The sequential development procedure was to verify the dispersion terms, both longitudinal and lateral, by using low winter flow inputs to the Bay thereby reducing the advection term to a negligible quantity and the decay and reaeration terms to zero. When the observed winter chloride distribution was reproduced, the dispersion coefficients were considered acceptable. The second step was to increase the freshwater flow inputs to the higher values observed during the summer months and, by reproducing the summer chloride distribution, verify the advective term in the equations. At this point it is possible to extrapolate to different conditions of freshwater inflow in terms of both quantity and location of input. This permits evaluation of several alternatives with respect to flow diversion. It may also be used for commenting on proposals for removal or placing of spoil from dredging and selective dredging to improve circulation.

Once the dispersion and advective terms have been established, non-conservative inputs can be examined and the decay term verified. Finally, the reaeration coefficient is established by reproduction of the dissolved oxygen distribution. Extrapolations may then be made with respect to carbonaceous waste removal, reduction of nutrient input, particularly nitrogen, and location of outfalls.

The segmenting of Hillsborough Bay is shown in Figure 12.1. The boundaries were chosen to give approximately equal depths within each segment. Where water quality parameters were changing rapidly with respect to distance such as at the mouths of tributaries and in the main channels, or where an accurate definition was most critical such as along the western shore, the surface area was smaller and consequently the number of segments was greater.

The observed chloride distribution during the months of December, January, February and March of 1967 and 1968 are shown in Figure 12.2. Long term data were considered necessary to minimize the

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(21)"Mathematical Model for Dissolved Oxygen" by R. V. Thomann, Journal of the Sanitary Engineering Division, ASCE, October 1963.

(22)"A Steady State Segmented Estuary Model" by R. E. Bunce and L. J. Hetling, Technical Paper No. 11, Middle Atlantic Region, FWPCA, Charlottesville, Virginia.

effects of essentially unsteady state occurrences such as wind effects, localized rainfalls and temporary disturbances due to improper diking caused by the filling of large areas of McKay Bay. During this period, the average freshwater discharge to Hillsborough Bay from the three major tributaries was 42.3% of the expected annual inflow based on hydrological records. The respective runoffs from each source were: Hillsborough River, 0.14 cfs; Alafia River, 240 cfs; Palm River, 30 cfs. The discharge from the Tampa sewage treatment plant was 38.5 cfs. Actual discharge from the Tampa water supply reservoir was 12 cfs. The remainder of the flow resulted from the Sulfur Springs discharge. Under these low flow conditions, advection or net flow movement and vertical stratification were not significant in Hillsborough Bay. The most significant factor affecting mixing and distribution in the Bay, particularly in the upper reaches above the Alafia River and along the western shore, was dispersion, both laterally and longitudinally, due to tidal action. The initial coefficients of dispersion were determined from a consideration of dye tracer and current velocity data.(23) They ranged from 0.70 square miles per day to 6.00 square miles per day with most of the coefficients being less than 2.0 square miles per day. These figures are quite low when compared with one-dimensional longitudinal estuaries where current velocity and direction are well defined. Hillsborough Bay is typical of Gulf Coast estuaries which are generally shallow and have irregular, very weak tidal and current fluctuations. The calculated chloride concentrations in each segment are listed also on Figure 12.2. The largest difference between observed and calculated values is in segment 11 or the upper western shore of the Bay. The observed chloride concentration was 14.1 g/l and the calculated value shows 15.0 g/l. However, during March 1968, the chlorides at this station averaged 11.7 g/l with values as low as 1.1 g/l, indicating a localized source of freshwater. When these values are eliminated, the average concentration in this segment was 14.9 g/l. Likewise, in segment 33, the sampling station was located adjacent to the MacDill sewage treatment plant outfall. Because the flow from this plant is so small, it was considered a localized phenomenon and not representative of the actual chloride concentration in the segment. With these exceptions, the winter chloride distribution for 1967-68 was reproduced with acceptable precision, particularly in the upper reaches of the Bay where water quality is most critical. The dispersion coefficients were then considered constant for any flow condition. During the process of verification of the dispersion, it was apparent that the system was relatively insensitive to modifications in the coefficients. Therefore, the provision of constant dispersion under all flow conditions was considered a reasonable assumption.

The verification of the advection, or net flow term, was more difficult since an initial flow distribution from each tributary and freshwater input location was required. This initial distribution was constructed utilizing data from the dye tracer as well as the current direction and intensity studies conducted during high flow periods. The chloride concentrations in the months of August, September, and October, 1967, were chosen for the advective verification and these are illustrated in Figure 12.3. During this time, the major part of the Gracilaria crop died and decayed in the waters along the upper western shore producing the intense odors. The inflow from the tributaries during this period were: Hillsborough River, 1197 cfs; Alafia River, 1149 cfs; and Palm River, 169 cfs. However, there was a great variation in flow with the maximum flows occurring in August and decreasing gradually to expected values in October. This was reflected in a wide range of observed chlorides with some sampling variations being as much as 50% of the mean value. There was also distinct vertical stratification at the mouths of the tributaries and in the upper reaches of the channelized sections. No significant stratification was observed outside these areas. This vertical stratification was not taken into account at this time and each segment was considered homogeneous. Future modifications of the distribution of conservative and nonconservative material through this simulation will account for stratification under high flow conditions by adjusting the area and volume elements.

The most critical area of verification during high flow periods is along the western shore and only very small deviations from the observed could be tolerated. The final accepted calculated values are also shown on Figure 12.3. The average deviation from observed values, excluding the Alafia River channel, is about 6% when considering absolute values, or 10% when considering the range of average values throughout the Bay, again excluding those in the Alafia channel. Along the western shore the average deviation is about 2%. The observed values of chlorides in the Alafia channel are inexplicable in terms of water movement. Therefore, projections of the effect of Alafia River

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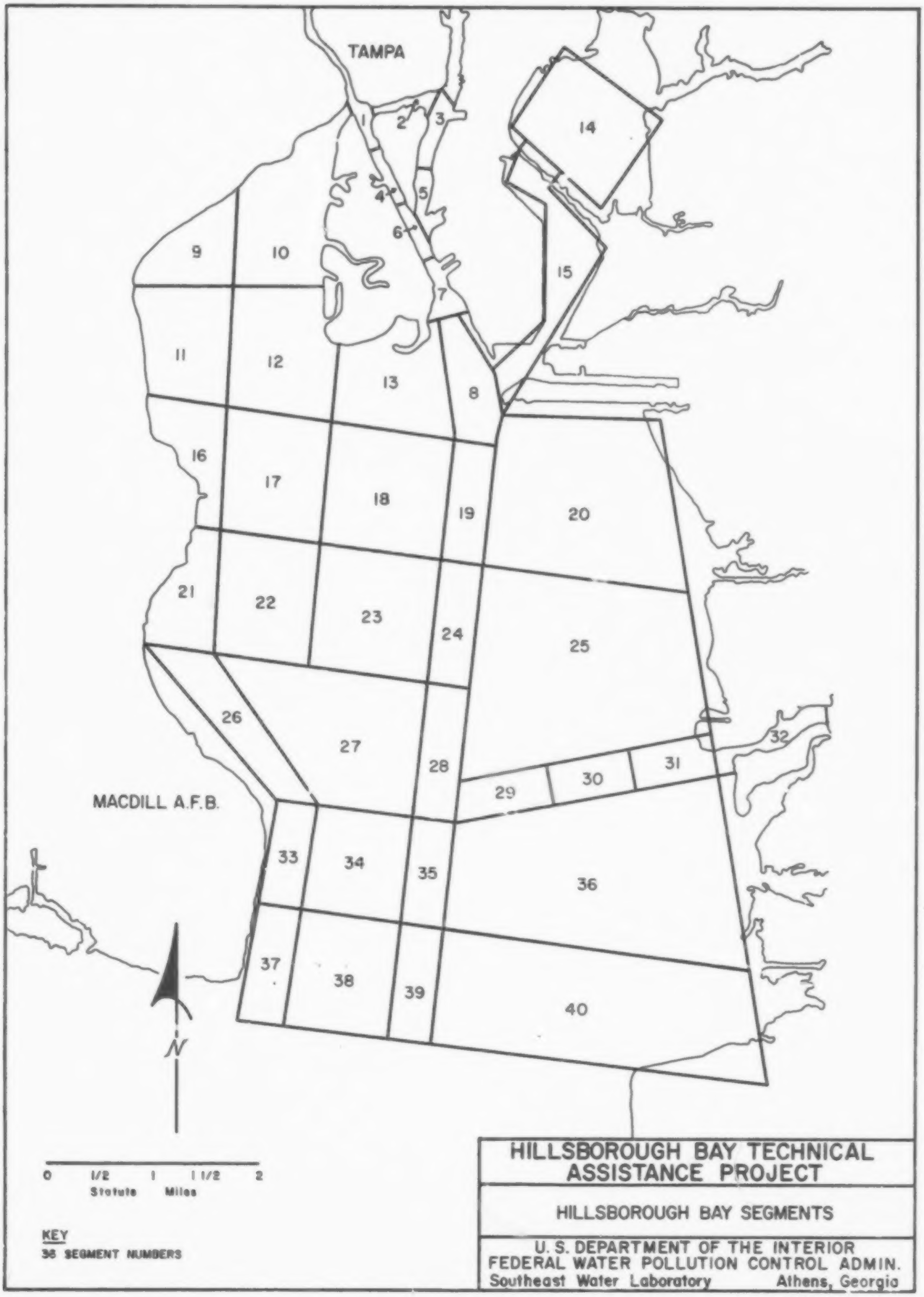
(23) A Discussion and Tabulation of Diffusion Coefficients for Tidal Waters Computed as a Function of Velocity by R. E. Bunce, Technical Paper No. 9, Middle Atlantic Region, FWPCA, February 1967.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36
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38
39
40
MACDILL A.F.B.
N
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Statute Miles
KEY
36 SEGMENT NUMBERS

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

HILLSBOROUGH BAY SEGMENTS

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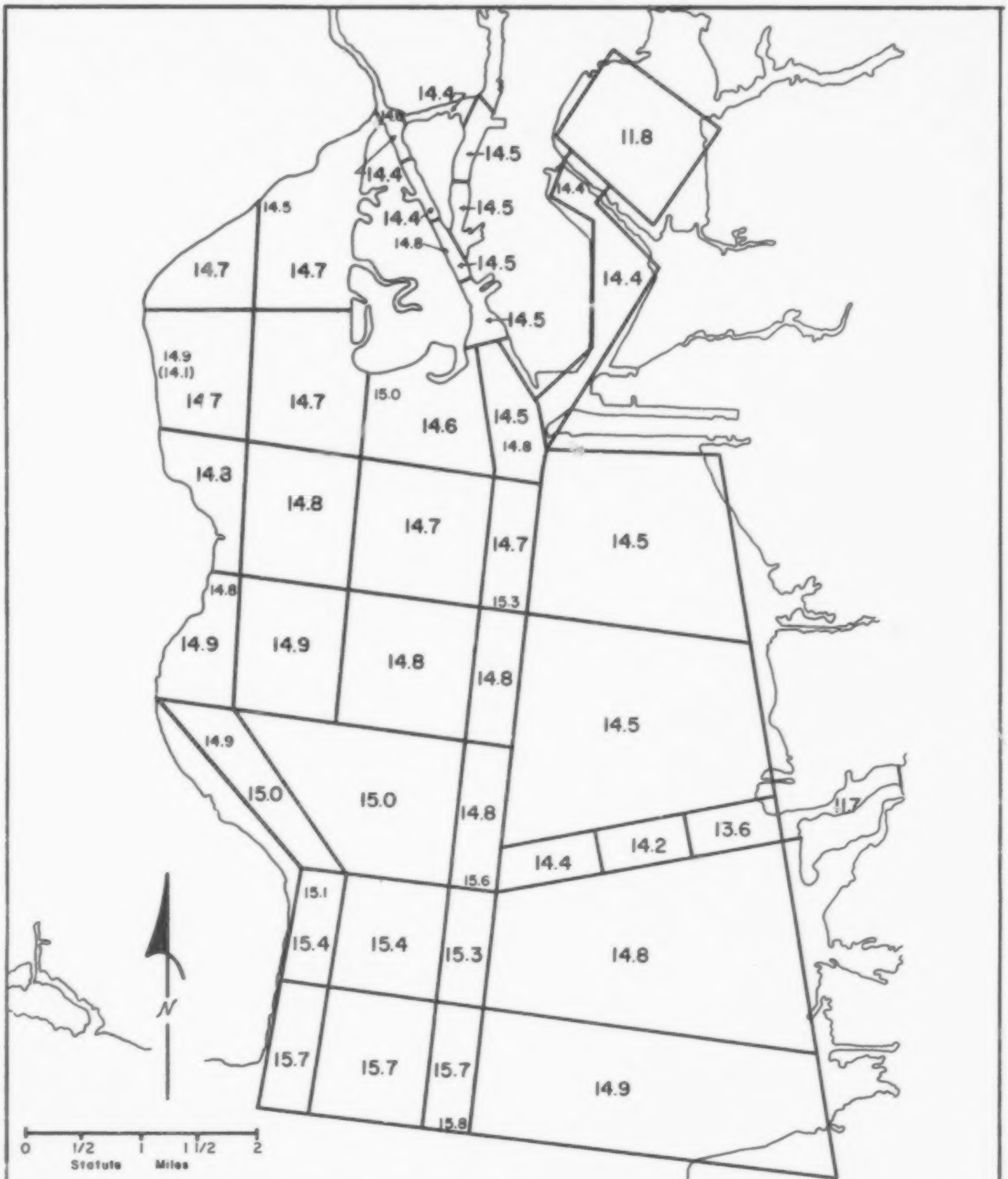
FIGURE 12.1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15.0
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13.6
15.6
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15.3
14.8
15.7
15.7
15.7
14.9
15.8
N
0
1/2
1
1 1/2
2
Statute Miles

FRESH WATER INFLOW

1. HILLSBOROUGH RIVER 14 cfs
2. ALAFIA RIVER 240 cfs
3. PALM RIVER 30 cfs
4. TAMPA S.T.P. 43 cfs

KEY

12.8 OBSERVED VALUES

12.8 CALCULATED VALUES

HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

CHLORIDE CONCENTRATION IN g/l
DEC., JAN., FEB. & MARCH, 1967-68

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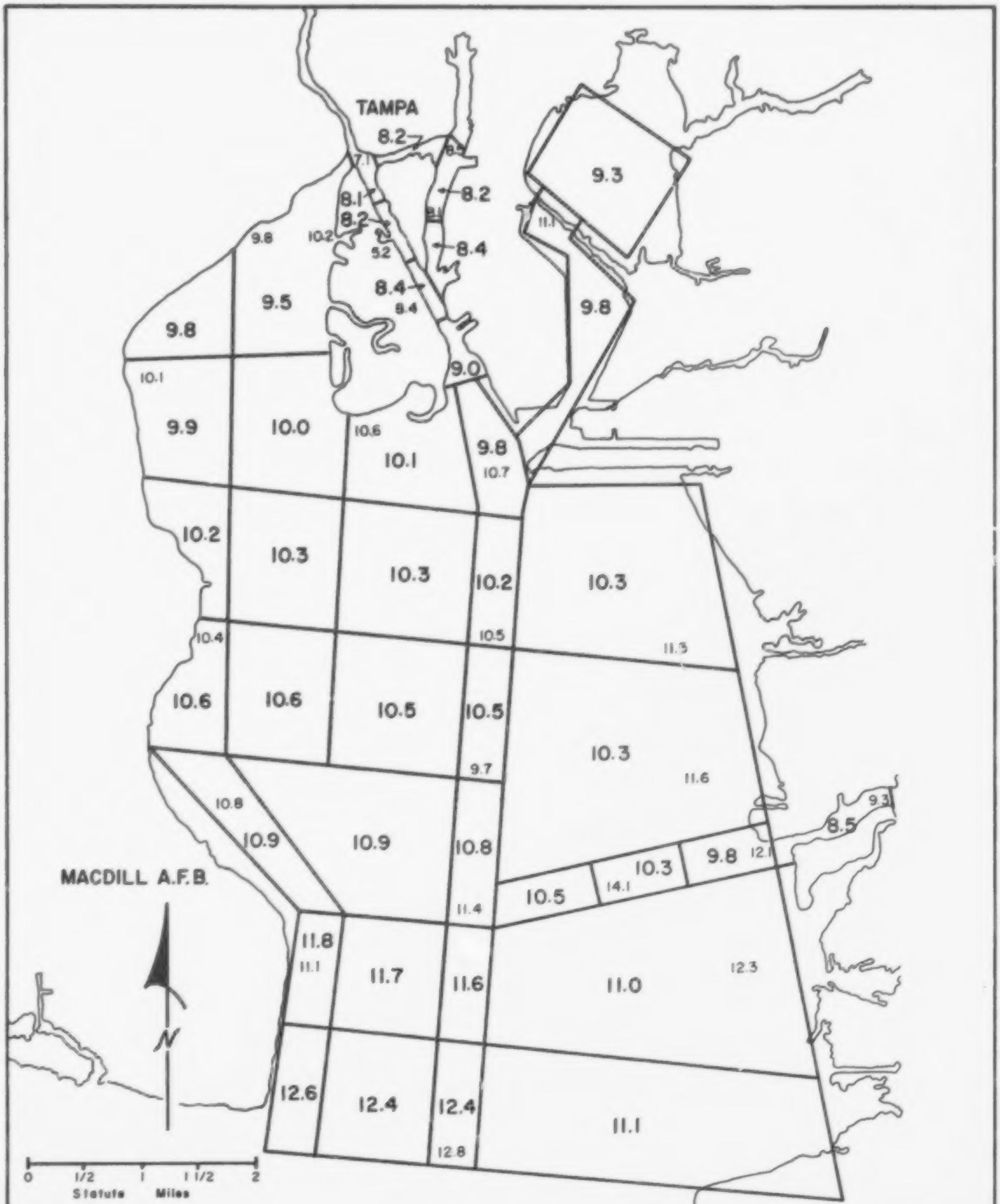
Southeast Water Laboratory Athens, Georgia

FIGURE 12.2

39-b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10.2
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9.8
8.4
8.4
9.3
11.1
9.8
9.5
9.8
9.0
10.1
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8.5
12.1
9.8
10.3
14.1
10.5
MACDILL A.F.B.
11.4
11.8
11.1
11.7
11.6
11.0
12.3
N
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12.4
12.4
11.1
12.8
0
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1
1 1/2
2
Statute Miles

FRESH WATER INFLOW

1. HILLSBOROUGH RIVER 1197 cfs
2. ALAFIA RIVER 1149 cfs
3. PALM RIVER 159 cfs
4. TAMPA S.T.P. 43 cfs

KEY

12.8 OBSERVED VALUES
12.8 CALCULATED VALUES

HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

CHLORIDE CONCENTRATION

AUGUST, SEPTEMBER & OCTOBER, 1967

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

FIGURE 12.3

39-C

flows should be considered in order of magnitude only and should not be used with quantitative precision at this time. In any case, these flows do not affect the critical areas along the western shore and in the upper reaches of the main ship channel.

Initially, the calculated values along the western shore were invariably higher than the observed values, indicating that a greater amount of freshwater was present than that advected from the tributaries, principally the Hillsborough River. It is not unreasonable to assume that this difference reflects the effect of direct runoff of storm water during this period of heavy rainfall. The percentage of the total drainage area to Hillsborough Bay represented by the land area immediately adjacent to the Bay is about 2%. To account for storm water runoff during the high flow period examined, a source of freshwater equal to 2% of the total observed tributary inflow to Hillsborough Bay was introduced directly into the segments along the shoreline. The average effect of the storm water lowered chloride concentrations along the western shore about 0.8 g/l or about 7%. Therefore, depending upon the flow from the Hillsborough River, storm water runoff could be one of the most critical factors affecting the Gracilaria standing crop. To mitigate this contributing factor to the odor problem, storm sewers should be extended beyond the 3.5 foot depth line. The following projections contain the effect of storm water on the same percentage basis described above.

During August 1967, the Hillsborough River had an average discharge of 2575 cfs; the Alafia River discharged 2126 cfs, and the Palm River 169 cfs. Substantial reductions in Gracilaria standing crop and widespread reports of odor were observed along the upper western shore north of Ballast Point. A simulation, utilizing these flow inputs and the Tampa sewage treatment plant effluent of 28 MGD, shows that the chloride concentration along the entire western shore north of Ballast Point was less than 6 g/l, the critical concentration for the death and decay of Gracilaria. The observed data during this period also were less than 6 g/l.

The maximum one in 10-year expected monthly flow in the Hillsborough River occurs in September and will be approximately 5600 cfs (see Table 6.1). The September once in 10-year flow in the Alafia River is 1950 cfs. A projection was made using these figures, together with 150 cfs input from the Palm River and 28 MGD from the Tampa sewage treatment plant, to obtain an indication of the effect of a relatively rare combination of high flows. This would presumably result in the most widespread odor occurrences with respect to both time and location. It is not known what the exact probability is of this combination flows since a correlation analysis of discharge probabilities in the Alafia and Hillsborough Rivers has not been made, but since both rivers drain essentially the same topography, it is likely that the probability of this combination would not be much less than once in ten. Flows of this magnitude would occur with a greater probability as the duration interval was lessened to weeks instead of a month. Under these conditions, all of Hillsborough Bay above a line between the Alafia River and Catfish Point would have chloride concentrations less than 6 g/l. All of the Gracilaria crop north of this line would be affected and would cause odors. By comparison for the previous projection of 2575 cfs from the Hillsborough River all of Hillsborough Bay north of a line between Port Sutton and just above Ballast Point was less than 6 g/l.

Figure 12.4 has been constructed using the projections discussed and others to show a comparison of the expected effect of Hillsborough River flows on odors along the western shoreline. Two indices of odor occurrence may be postulated. Since odor is directly related to the decay of Gracilaria under low chloride concentrations, the percentage of the standing crop affected would be a direct indicator. This assumes that the distribution of Gracilaria along the shoreline, as observed during this study, would remain essentially constant (see Chapter 10). Another index would be the percentage of shoreline affected which presumably would reflect the percentage of residents affected; and, therefore, the expected number of complaints; again assuming the distribution of population along the shoreline to be relatively homogeneous, which is valid in this case.

Inspection of the figure shows that the initial effect occurs at a Hillsborough River discharge of 2400 cfs. This agrees excellently with a regression analysis which related observed Hillsborough River flows of 2400 cfs to observed chloride concentrations of 6 g/l along the upper western shore. The effect is very pronounced for Hillsborough River flows between 2400 and about 3000 cfs. This range of flow will affect 35% of the standing crop and 58% of the shoreline. The standing crop is not uniformly distributed. Almost 50% of the Gracilaria grows between Catfish Point and Gadsden Point. Therefore, it requires large increases in flow to affect further small increments of the Gracilaria crop. This would also explain why the reporting of hydrogen sulfide odors in this area is very rare. By the other criterion, a majority of the inhabitants will be affected between discharges of 2400 and 3000 cfs from the Hillsborough River. Since this is the origin of the complaints, it is probably the more significant indicator.

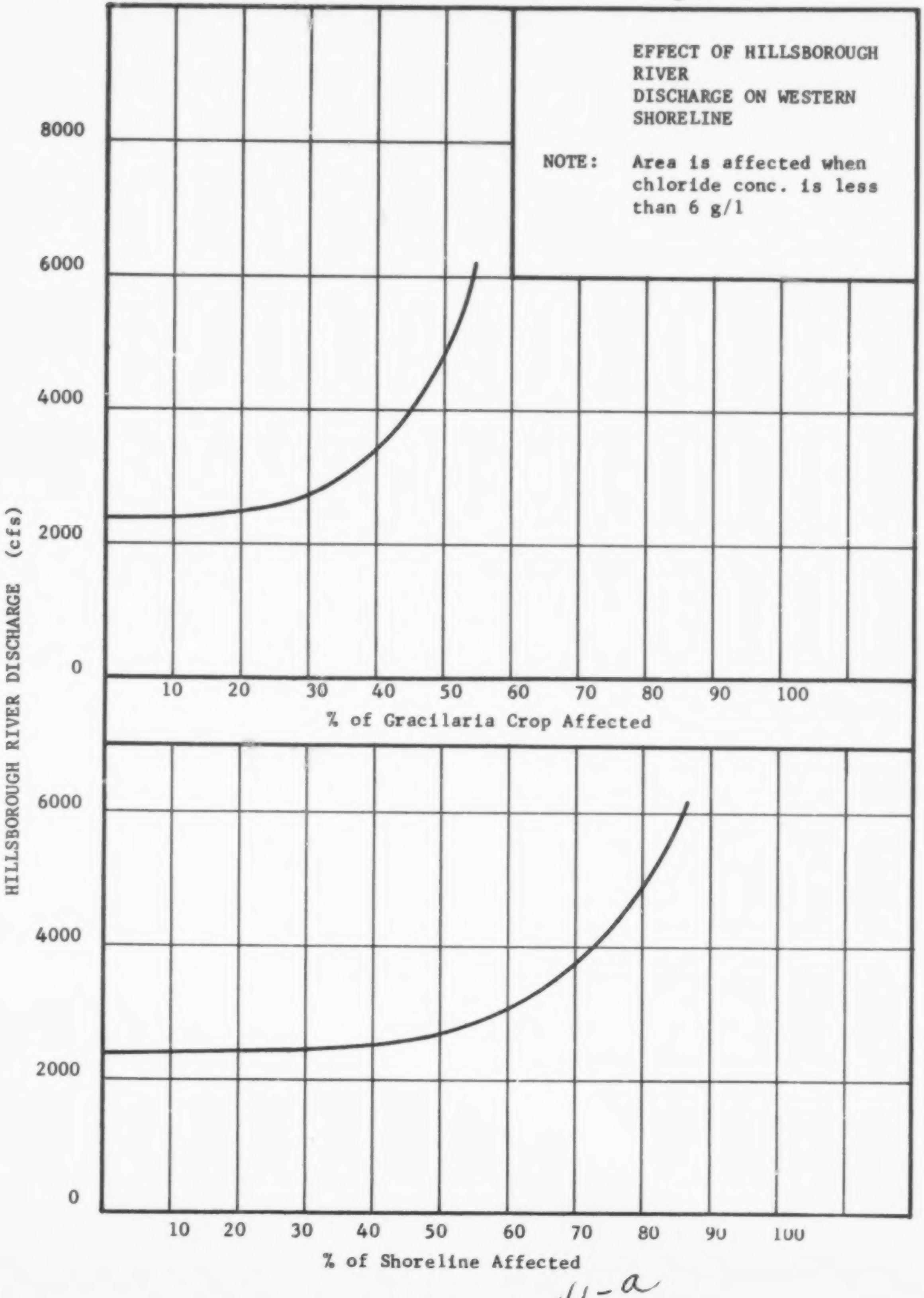
This analysis shows that the expected occurrence and frequency of odor is very sensitive to flows which have been occurring at a relatively high frequency during the summer months, particularly in August and September. To prevent the death and decay of Gracilaria in shallow water during these warm months, the freshwater discharge from the Hillsborough River should not exceed 2000 cfs at any time. This discharge can be controlled at the Tampa water supply reservoir.

As part of the Four Rivers Basin Project, the Southwest Florida Water Management District and the U. S. Army Corps of Engineers propose to divert water out of the Hillsborough River basin and into the Sixmile Creek-Palm River basin. Although specific discharge figures are not yet fully decided upon, an estimate of the maximum flow from the Hillsborough River after diversion is 1200 cfs and the corresponding discharge from the Palm River would be 2000 cfs. Assuming a flow of 1500 cfs from the Alafia River, a projection of chloride concentrations in Hillsborough Bay under these conditions was made. The results are shown in Figure 12.5. The distribution of chlorides demonstrates again that the overwhelming effect on western shore concentrations is a function of Hillsborough River flows. However, comparison with Figure 12.3 does show that, for essentially the same flow input from the Hillsborough River and an increase in flow in the Palm River from 169 cfs to 2000 cfs, concentrations along the western shore are reduced 7-10%. Therefore, the chlorides in this area are slightly sensitive to Palm River flows. It is much more preferable, though, to introduce excess freshwater through the Palm River since introduction through the Hillsborough River would have reduced chloride concentrations below 6 g/l along more than 60% of the western shoreline thereby causing intense odors. From the standpoint of odor production and water quality in Hillsborough Bay, this flow diversion alternative of the Four Rivers Basin Project is a desirable development. The same procedure for evaluating this alternative can be used to analyze and design quantity and location of input of material to Hillsborough Bay, whether it be from waste sources or water resource projects, since it provides estimates of the sensitivity of critical water quality areas to these criteria.

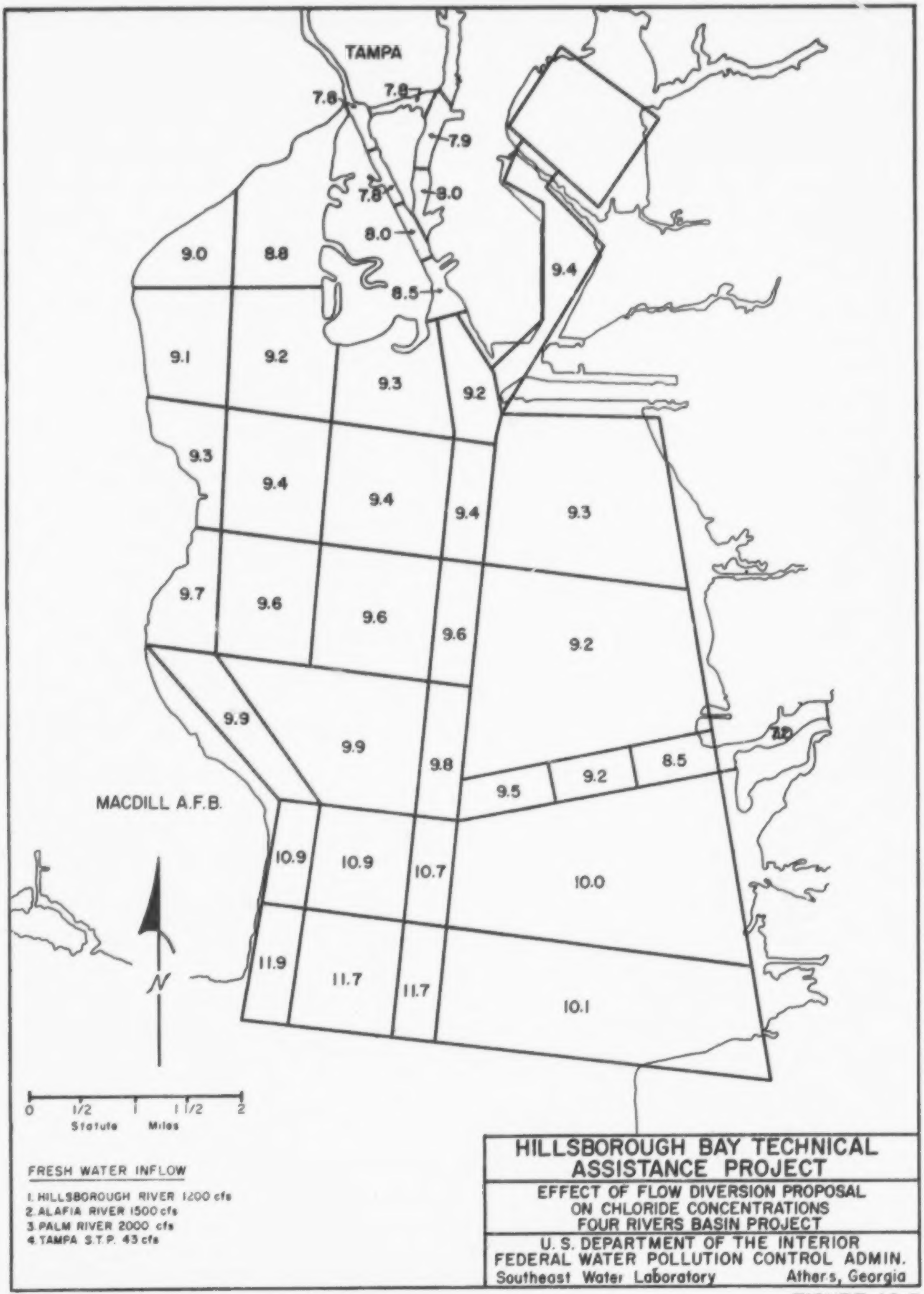
Of course, these recommendations will only maintain chloride concentrations above 6 g/l along the western shore and prevent the unnatural death and decay of the Gracilaria. It will not correct the ultimate problem of poor water quality and excessive nitrogen and phosphorus discharges from point sources that produce the conditions which permit the excessive growths of Gracilaria to occur in the first place. Unless these conditions are corrected and/or unless the Gracilaria is harvested and removed and a diversified ecosystem restored, the natural annual life cycle of this benthic algae will continue the death and decay process regularly, albeit during months with cooler water temperatures and higher salinities, odors are less intense and noticeable. The basic problem will remain unless the recommendations discussed in previous sections of this chapter are implemented.

To meet the immediate objectives of this Project, only the conservative or inorganic material distribution has been verified. Work is continuing toward simulation and verification of the nonconservative or organic parameters. When completed, this mathematical model will be a necessary component to evaluating specific proposals for water quality management and water resources development in Hillsborough Bay made by Federal, State and local authorities. For example, the Corps of Engineers had had under consideration for many years the construction of a hurricane barrier across the mouth of Hillsborough Bay. The effect on water quality can be projected through this simulation. Consideration can also be given to proposals for outfall location, dredging and filling operations, selective dredging of intense organic deposits, nutrient reduction and complete removal of deleterious waste material.

Figure I2.4



41-a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Statute Miles
FRESH WATER INFLOW
1. HILLSBOROUGH RIVER 1200 cfs
2. ALAFIA RIVER 1500 cfs
3. PALM RIVER 2000 cfs
4. TAMPA S.T.P. 43 cfs

HILLSBOROUGH BAY TECHNICAL
ASSISTANCE PROJECT

EFFECT OF FLOW DIVERSION PROPOSAL
ON CHLORIDE CONCENTRATIONS
FOUR RIVERS BASIN PROJECT

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

FIGURE 12.5

41-4

13.

ABATEMENT

In prior sections, waste sources have been identified and quantified, water quality has been measured, and the causes of the obnoxious odors have been determined in laboratory tests and verified by field studies. It now remains to recommend means and methods of modifying existing conditions to abate the odors and make the aquatic environment suitable for other desirable uses.

Present conditions did not occur suddenly; the odors and the water quality degradation have developed over many years of inadequately controlled waste discharge. Similarly, abatement will not be immediate nor will it be accomplished by a single treatment plant or a single regulatory agency. The continued growth and development of the Tampa area will result in increased pollutional load to the Bay unless strict and enforceable water quality standards and treatment regulations are adopted and implemented.

Immediate Steps to Abate Odors

The odors emanating from Hillsborough Bay are symptomatic indications of a severe ecological imbalance. The only way to correct this situation is to re-establish a balanced ecosystem. However, there are several interim measures which, if taken, may reduce the frequency and severity of the odor.

It has been amply demonstrated that decaying Gracilaria is responsible for the obnoxious odors. The removal of this material prior to its decay would remove the causative agent, thereby reducing the odor. Three methods are available to accomplish this removal: (1) policing the shoreline and intertidal zone to remove Gracilaria and other debris; (2) mechanical harvesting of Gracilaria; and (3) offshore fencing to prevent accumulation on the beach.

Along the shoreline of MacDill Air Force Base, the musty vegetative odor results from material deposited on the beach to water quality. The removal of plant material from the beach and intertidal zone should be sufficient to prevent decay and alleviate these odors.

Along Bayshore Boulevard, the cutting hydrogen sulfide odor results when Gracilaria decays in the water under anaerobic conditions. Removal of material from the intertidal zone should greatly reduce the odors provided the removal is frequent enough to prevent the accumulation of material in the dead pockets near Bay-to-Bay Boulevard and Hawthorne Street. Presence of the seawall makes this area less accessible and therefore more difficult to police than the beaches along Ballast Point and MacDill Air Force Base.

Policing the shoreline and intertidal zone has two long range benefits in addition to the immediate reduction of odor producing potential: (1) removal of unsightly algae and debris improves the appearance and aesthetic enjoyment of the adjacent parkway, playground, yacht club, and beach; (2) it removes from the Bay system the oxygen demand and the nutrients which would otherwise be recycled within the system.

It is, therefore, recommended that the city of Tampa and MacDill Air Force Base initiate prior to this summer's odor period, a continuing program to remove Gracilaria and other debris from the intertidal zone of Hillsborough Bay from the Hillsborough River to Gadsden Point.

Mechanical harvesting of Gracilaria has been suggested as an immediate control measure. Arguments in favor of harvesting are the same as those for policing with the added advantage that a commercial market might be available for healthy Gracilaria. If this alternative should be taken, harvesting should be done during April and May when the standing crop is increasing and before the onset of summer rains. Aerial reconnaissance would readily reveal the areas of highest crop density where harvesting would be most efficient. The disadvantage of this alternative is that presently available harvesting equipment requires a depth of at least two feet and therefore could not reach the area immediately adjacent to shore except at high tide.

Fencing in shoreline areas to about the 1.5 foot depth contour (MLW) would prevent the shoreward migration of Gracilaria and, if used in conjunction with mechanical harvesting, it would concentrate the material and make harvesting more efficient. It would also reduce the amount of material to be handled in policing operations.

As an immediate stop-gap measure to reduce H_2S odors after they are detected, chemical agents may be added to counteract the hydrogen sulfide. Sodium hypochlorite has proved effective for reducing sulfides. Care should be exercised in chemical selections to avoid the use of nitrogen compounds which would add nutrients to the Bay.

To Meet Present Water Quality Standards

Water quality standards applicable to Hillsborough Bay under its present classification of Class IV are being violated. Dissolved oxygen falls below the minimum allowable 4.0 mg/l for extended periods during the summer. This is a result of (1) the oxygen demanding materials discharged from the Tampa primary sewage treatment plant, and (2) the oxygen demand of organic benthic materials. The principle abatement procedure required to correct this condition is secondary sewage treatment for the city of Tampa and post chlorination at the Hookers Point plant.

A well-operated conventional or high rate biological secondary treatment plant can be expected to remove about 85-90% of the carbonaceous biochemical oxygen demand (B.O.D.) and 92-95% of the suspended solids. In the case of the Tampa plant, this would result in the discharge of 7350 pounds/day of 5-day B.O.D., 9900 pounds/day of ultimate B.O.D., and 1500 pounds/day of suspended solids. The city of Tampa is presently under order from the Florida Department of Air and Water Pollution Control to provide secondary treatment.

MacDill Air Force Base is in the final design stage for conversion of the existing primary treatment plant to biological secondary treatment. That project should be completed as rapidly as possible.

Post chlorination should be included as an integral part of both the Tampa and MacDill treatment plants. This would provide suitable bacteriological water quality at the Gadsden Point recreational area. It is estimated by simple linear reduction that this would reduce the mean coliform bacteria density at stations B9 and B10-T to 16 and 52 respectively, well within the allowable limit for primary contact recreation.

To Establish a Diversified Ecology

In order to abate the odor permanently and upgrade water quality to allow a wide range of desirable water uses, it will be necessary to reduce or remove present waste inputs and re-establish a diversified ecology to Hillsborough Bay. To accomplish this objective several specific measures are required.

The Florida Department of Air and Water Pollution Control should immediately upgrade the water use classification of Hillsborough Bay south and west of Davis Island to Class III: recreation and propagation of fish. This action would establish a stronger legal and regulatory base from which engineering abatement procedures could be pursued.

It should be noted that conventional secondary treatment of the Tampa and MacDill Air Force Base sewage treatment plants will not significantly reduce the occurrence of odors along the western shore, nor will this measure alone redress the unbalanced ecology of the Bay which has been discussed in previous sections. Primary nutrients must be controlled to a level that will reduce the present nuisance growth of phytoplankton and Gracilaria.

Nitrogen is the growth limiting primary nutrient in Hillsborough Bay. Any reduction in available nitrogen could be expected to produce corresponding reductions in growth. Official water quality criteria are not available for nitrogen compounds. The Waccasassa estuary had levels of nitrate of 0.01 mg/l and nitrite levels in the Gulf were reported to be about 0.03 mg/l. For this study, a total of 0.03 mg/l of nitrate and ammonia will be used as the water quality objective. This will require at least 90% reduction of present total nitrogen concentrations from the Tampa sewage treatment plant, Nitram Chemicals Company, U. S. Phosphoric Products Company and ammonia producing phosphate processing industries on the Alafia River.

Phosphorus is the other primary nutrient affecting the growth of nuisance vegetation in Hillsborough Bay. The major sources of phosphates to the Hillsborough Bay system are the phosphate processing plants on the headwaters of the Alafia River and U. S. Phosphoric Products Company. These sources must provide phosphate removal to the highest degree possible. One order of magnitude reduction (90 percent) would result in 0.3 mg/l concentrations, and a second order of magnitude reduction (99%) would result in 0.03 mg/l concentrations in the Bay. It is recommended that phosphate industry plants and all other waste sources previously noted proceed with the construction and operation of facilities to reduce phosphate concentration to approximately 0.03 mg/l in Hillsborough Bay.

It has been demonstrated that chlorosity of 6.0 g/l Cl^- kills Gracilaria and leads to the production of obnoxious odors. Regression analysis and mathematical simulation of chlorosity along Bayshore Boulevard from the Hillsborough River to Ballast Point indicate that the maximum flow that may be discharged and still maintain the required chlorosity of 6.0 g/l is 2400 cfs at the Tampa water supply reservoir. It is recommended that the Southwest Florida Water Management District and the Corps of Engineers include in the Hillsborough River phase of the Four Rivers Basin Project adequate storage to keep the maximum daily discharge at or below 2000 cfs.

One alternative which has been suggested to keep Hillsborough River flow from the Bayshore Boulevard area is to construct a barrier or fill the channel between Bayshore Boulevard and Davis Island in the vicinity of the existing bridges. This would certainly divert the flow, but would have two adverse consequences: (1) it would further limit recreational boating in the Bay by eliminating the connection between the Hillsborough River and the Bay and force pleasure boats to pass through the highly commercial port and harbor area, and (2) it would create a cul-de-sac between Davis Island and Bayshore Boulevard in which flushing would be reduced and the water would be subject to further degradation. Therefore, this alternative is not recommended.

Storm sewers which discharge immediately adjacent to the seawall along Bayshore Boulevard directly into areas of high Gracilaria density cause a localized drop in chloride concentrations. Odor panel and standing crop studies show that a significant loss of standing crop and obnoxious odors occur prior to the peak runoff from the Hillsborough River. To abate this localized odor nuisance, it is recommended that storm sewers be extended beyond the area of high standing crop (3½ feet depth contour).

Construction and maintenance dredging have altered the configuration of Hillsborough Bay so that the normal flood and ebb current patterns have been altered. Two projects presently under study by Corps of Engineers would further alter this pattern. Widening the existing channel by 100 feet and deepening it to 40 feet (MLW) would create an estimated 18 million cubic yards of spoil in the main shipping channel (Cut C channel) alone. Deepening of the Alafia Channel to 40 feet would produce approximately four million cubic yards of spoil. Indiscriminate disposal of this material in existing spoil sites could further alter current patterns. Also, construction of a hurricane barrier across the mouth of Hillsborough Bay could alter the hydraulic characteristics of the Bay.

Hydraulic model studies should be used to verify the insights developed through the mathematical simulation with respect to improving tidal flushing and exchange with Tampa Bay through the proper placement and alignment of spoil banks. Continued development and growth of the port of Tampa as a major economic factor makes expansion of the present channels inevitable. If any benefit to water quality may result incidental to such a project, it should be determined and utilized. Congress has authorized the construction of a hydraulic model of Tampa Bay. No further construction dredging should be done in the Bay until the hydraulic model is available to study the possible consequences. Maintenance dredging spoil should be completely removed from the Bay system.

Rehabilitation

The previous recommendations have been concerned with the elimination of practices which in the past have led to the present degraded water quality and obnoxious odors. If these objectives are accomplished, nature may through its processes of self purification, eventually restore Hillsborough Bay to a healthy aquatic environment. It will be the purpose of the following discussion to recommend means of speeding the natural processes.

To speed the stabilization of accumulated benthic materials and remove that reservoir of oxygen demand and nutrients, those materials should be removed from selected areas. Maintenance dredging in the Cut D channel, Cut C channel, and Alafia Channel should be done by hopper dredge and the material discharged in the Gulf of Mexico. The maintenance spoil site immediately south of Davis Island should be abandoned. In addition, dredging in areas where organic carbon is greater than 3.0 percent (Figure 9.8) and removal of those high organic deposits from the Bay would speed the natural purification processes and remove a significant nutrient reservoir.

The practice of shell dredging in the lower Bay should be periodically reviewed. This practice disturbs bottom sediments and causes high suspended solids in the immediate area of the dredging and washing operations. At such time as the input sources of solids are controlled, the practice should be discontinued.

APPENDICES

APPENDIX

TABLE OF CONTENTS

Appendix

A.1	Correspondence and Requests for Technical Assistance
A.2	Hillsborough River Discharge
A.3	Alafia River Discharge
A.4	Palm River (Sixmile Creek) Discharge
A.5	Total Freshwater Discharge to Hillsborough Bay
A.6	Major Waste Sources
A.7	Chemical and Bacteriological Analytical Procedures
A.8	Field Sampling Procedures
A.9	Sampling Station Descriptions
A.10	Analytical Results
A.11	Fecal Coliform Data
A.12	Planning and Scheduling Projections

APPENDIX

A.1

T M CUMFIE PH G VICE PRESIDENT
QUINCY
LEO M WACHTEL M D MEMBER
JACKSONVILLE

EUGENE G PEEK JR M D PRESIDENT
OCALA

WILLIAM O SHUMPERT D D S MEMBER
FORT LAUDERDALE
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Florida State Board of Health

WILSON T SOWDER M.D., M.P.H., STATE HEALTH OFFICER
MALCOLM J FORD M D M P H DEPUTY STATE HEALTH OFFICER

JACKSONVILLE, 32201

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BOX 210

UREAU OF SANITARY ENGINEERING
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DIRECTOR
SIDNEY A. BERKOWITZ, M.S. IN ENG.
ASSISTANT DIRECTOR

DIVISION OF WATER SUPPLY
J. B. MILLER, M.P.H.
DIRECTOR
DIVISION OF SPECIAL SERVICES
CHARLES E. COOK, C.E.
DIRECTOR
DIVISION OF WASTE WATER
RALPH H. BAKER, JR., M.S.S.E.
DIRECTOR
DIVISION OF INDUSTRIAL WASTE
VINCENT D. PATTON, M.S.S.E.
DIRECTOR

May 4, 1965

IN REPLY PLEASE REFER TO

Hillsborough Co. /1
Hillsborough Bay (Odor Problem)

Mr. Herbert H. Rogers
Regional Program Director
Water Supply & Pollution Control
Region IV, U. S. Public Health Service
Room 404, 50 Seventh Street, N.E.
Atlanta 23, Georgia.

Dear Mr. Rogers:

We are sure you are familiar with our activities and study of the causes of noxious odors emanating from Hillsborough Bay, Hillsborough County, Florida, and these being the alleged cause of discomfort at MacDill Air Force Base.

We have submitted our report and there still seems to be a great deal of discussion and uncertainty. We are hopeful that your agency and members of your staff can provide us with some technical services to run down the source and causes of this problem.

Your assistance will be greatly appreciated.

Cordially yours,

David B Lee

DBL/mws

David B. Lee

49-a

NICK NUCCIO
MAYOR

AMERICAN MUNICIPAL ASSOCIATION
FLORIDA LEAGUE OF MUNICIPALITIES

EXECUTIVE OFFICES

June 7, 1965

The Honorable Sam M. Gibbons
122 House Office Building
Washington, D. C. [illegible]

Dear Sam:

Recent efforts have been made by local agencies to determine the causes and a method of eliminating or controlling the obnoxious odors from Hillsborough Bay along Bayshore Boulevard and at the MacDill Field Airbase. Preliminary studies indicate the odors may be caused by the decomposition of marine life and the algal vegetation entrapping it when exposed to the air and sunlight, as a result of being washed upon the shoreline.

Possible solutions considered are too costly for the City to finance and some less expensive methods do not offer a positive solution.

Because of your thorough knowledge of this undesirable condition, I respectfully request that you bring this matter before the proper Federal Officials and agencies in the form of a request for assistance in making a determination of the causes and in providing the corrective measures. I am certain this can be justified for the benefit of MacDill Airbase as well as to preserve the natural and scenic environment of Hillsborough Bay and the adjacent shoreline.

I would also like for you to bring this matter to the attention of your colleagues from Florida in the Congress and Senate and enlist their help.

With kindest personal regards,

Cordially yours,

Mayor

49-t

NN/mm

Reproduced from best available copy.

JUN 9 1965

SAM M. GIBBONS
10th District, Florida

Room 1232, Longworth Building
Telephone 225-3376

District Office:
800 Zack Street
Tampa, Florida

Congreſs of the United States
House of Representatives
Washington, D. C.

Committees:
EDUCATION AND LABOR
HOUSE ADMINISTRATION

HECTOR ALCALDE
Administrative Assistant

June 10, 1965

Mr. Keith S. Krause
Chief, Technical Services Branch
Division of Water Supply and Pollution
Control
Public Health Service
Department of Health, Education, and
Welfare
Washington 25, D. C.

Dear Mr. Krause:

I am enclosing to you a copy of a letter which I have received from the Mayor of Tampa, asking for Federal participation in making a determination of the causes and in providing the corrective measures in connection with the obnoxious odors in Hillsborough Bay.

As you know from our previous conferences, I am extremely anxious to take every possible step to be helpful in this matter.

I shall appreciate hearing from you.

Sincerely,

Sam M. Gibbons

Sam M. Gibbons
United States Congressman

SMG:hc
Enclosure

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APPENDIX

A.2

Hillsborough Bay Technical
Assistance Project

Table A.2

HILLSBOROUGH RIVER DISCHARGE

Date	Expected Discharge[1] USGS Gage cfs	Actual Discharge USGS Gage cfs	% of Expected Discharge	Sulfur Springs Discharge cfs	Estimated[2] Total Discharge cfs
January 1967	240	104	43.3	43.9	158
February	240	277	115.4	40.9	344
March	260	107	41.2	38.6	156
April	160	5.9	3.7	18.2	25
May	110	2.6	2.4	8.4	11
June	175	7.5	4.3	22.5	31
July	510	340	66.7	46.3	419
August	1050	2299	219.0	57.2	2575
September	1200	610	50.8	56.7	725
October	610	124	20.3	59.2	195
November	240	18	7.5	39.9	60
December 1967	155	22	14.1	41.9	66
January 1968	240	20	8.3	40.0	62
February	240	4	1.6	31.3	36
March	260	4	1.5	32.9	37
April	160	1	0.6	8.6	10
May	110	2	1.8	4.8	7
June	175	372	212.5	34.2	442
July	510	2118	415.2	48.0	2368
August	1050	759	72.2	50.6	882
September	1200	1455	121.2	54.8	1648

1. Based on 28 years of record (1932-1960).
2. Estimated total Hillsborough River Discharge to Hillsborough Bay equals discharge at the USGS gage times basin factor plus discharge from Sulfur Springs. Basin factor equals the ratio of total drainage area to drainage area above gage: 690/630 = 1.09523.

APPENDIX

A.3

Table A.3

ALAFIA RIVER DISCHARGE

Date	Expected Discharge[1] USGS Gage cfs	Actual Discharge USGS Gage cfs	% of Expected Discharge	Lithia Springs Discharge cfs	Estimated[2] Total Discharge cfs
January 1967	170	192	112.9	38	278
February	185	330	178.4	41	454
March	190	215	113.2	36	305
April	138	122	88.4	24	176
May	74	79	106.4	21	120
June	210	209	99.5	26	287
July	450	486	108.0	43	650
August	590	1652	280.0	61	2126
September	600	512	85.3	70	710
October	315	314	99.6	64	456
November	150	147	98.0	49	233
December	140	180	128.5	39	264
January 1968	170	149	87.6	38	224
February	185	177	95.6	41	262
March	190	172	90.5	36	251
April	138	89	64.4	24	135
May	74	115	155.4	21	165
June	210	799	380.4	26	1025
July	450	1415	314.4	43	1812
August	590	479	81.1	61	660
September	600	924	154.0	70	1225

1. Based on 22 years of record (1938-1960).
2. Estimated Alafia River discharge to Hillsborough Bay equals discharge at USGS Gage times basin factor plus estimated Lithia Springs discharge. Basin factor equals the ratio of total drainage area to area above gage: 430/335 = 1.25.

APPENDIX

A.4

Hillsborough Bay Technical
Assistance Project

Table A.4

PALM RIVER (SIXMILE CREEK) DISCHARGE

Date	Expected Discharge[1] USGS Gage cfs	Actual Discharge USGS Gage cfs	% of Expected Discharge	Estimated[2] Total Discharge cfs
January 1967	44	35.7	81.1	51
February	44	52.2	118.6	75
March	105	40.8	38.9	58
April	68	23.4	34.4	34
May	50	20.3	40.6	29
June	58	44.1	76.0	63
July	96	43.7	45.5	62
August	150	118.	78.7	169
September	115	49.	42.6	70
October	56	42.	75.0	60
November	34	35.	102.9	50
December 1967	34	35.	102.9	50
January 1968	44	31.	70.4	44
February	44	28.	63.6	40
March	105	26.	24.7	37
April	68	21.	30.8	30
May	50	16.	32.0	23
June	58	65.	112.0	93
July	96	135.	140.6	193
August	150	53.	35.3	76
September	115	110.	95.6	157

1. Based on 4 years of record (1956-1960).
2. Estimated total Palm River (Sixmile Creek) discharge to Hillsborough Bay equals discharge at USGS Gage times basin factor. Basin factor equals the ratio of total drainage area to drainage area above gage: 40/28 = 1.43.

APPENDIX

A.5

Hillsborough Bay Technical
Assistance Project

Table A.5

TOTAL FRESH WATER DISCHARGE TO HILLSBOROUGH BAY[1]

Date	Expected Discharge USGS Gage cfs	Actual Discharge USGS Gage cfs	% of Expected Discharge	Estimated[2] Total Discharge cfs
January 1967	460	332	72.2	487
February	430	659	153.0	873
March	600	363	60.5	519
April	430	151	35.1	235
May	245	102	41.6	160
June	430	72	16.7	381
July	1200	870	72.5	1131
August	2250	4069	181.	4870
September	1770	1171	66.2	1505
October	1090	480	44.0	711
November	450	200	44.4	343
December 1967	365	237	64.9	380
January 1968	460	200	43.4	330
February	430	209	48.6	338
March	600	202	33.6	325
April	430	111	25.8	175
May	245	133	54.2	195
June	430	1236	287.	1560
July	1200	3668	306.	4373
August	2250	1291	573.	1618
September	1770	2489	141.	3030

1. Alafia River discharge plus Hillsborough River discharge plus Palm River (Sixmile Creek) discharge.

2. Total estimated from drainage basin ratios and adding the discharge from major springs.

APPENDIX

A.6

Hillsborough Bay Technical
Assistance Project

Table A.6

MAJOR WASTE SOURCES

Waste Input	5-Day B.O.D.		Ultimate B.O.D.		Total Filterable Residue		Volatile Filterable Residue	
	Mean 1000 No./day	% of Total Input	Mean 1000 No./day	% of Total Input	Mean 1000 No./day	% of Total Input	Mean 1000 No./day	% of Total Input
Alafia River (1)	3.96	6.9	5.79	7.4	16.76	22.9	8.75	24.1
Hillsborough River (1)	3.30	5.8	4.82	6.2	11.47	15.7	7.74	21.3
MacDill AFB STP (2)	0.64	1.1	0.82	1.1	0.34	0.5	0.27	0.8
Nitram Chemical Co. (3)	-------	-----	-------	-----	0.10	0.1	-------	-----
Palm River (Sixmile Ck.) (1)	0.45	0.8	0.66	0.8	3.57	4.9	1.85	5.1
Tampa STP (2)	49.0	85.4	66.0	84.5	25.9	35.4	17.7	48.7
U.S. Phosphoric Products (3)	-------	-----	-------	-----	14.94	20.5	-------	-----
TOTALS	57.35	100.0	78.09	100.0	73.08	100.0	36.31	100.0

(1) Based on weekly samples from June 1967 through April 1968.
(2) Based on weekly composite samples from June 1967 through April 1968.
(3) Estimates based on five 8-hour composite samples, flow measurements and company supplied flow estimates.

Hillsborough Bay Technical Assistance Project

Table A.6 (Cont'd.)

MAJOR WASTE SOURCES

Waste Input	Ammonia Nitrogen		Nitrate and Nitrite Nitrogen		Total Kjeldahl Nitrogen		Total Phosphate	
	Mean 1000 No./day	% of Total Input	Mean 1000 No./day	% of Total Input	Mean 1000 No./day	% of Total Input	Mean 1000 No./day	% of Total Input
Alafia River (1)	3.28	22.1	3.59	-----	3.45	20.4	43.47	78.0
Hillsborough River (1)	0.21	1.4	0.04	-----	0.91	5.4	0.63	1.1
MacDill AFB STP (2)	0.13	0.9	0.00	-----	0.14	0.8	0.05	0.1
Nitram Chemical Co. (3)	2.88	19.4	2.35	-----	2.88*	17.0	0.001	0.0
Palm River (Sixmile Ck.) (1)	0.07	0.5	0.10	-----	0.18	1.0	0.10	0.2
Tampa STP (2)	6.2	41.7	0.005	-----	7.3	43.1	2.7	4.8
U.S. Phosphoric Products (3)	2.08	14.0	&	-----	2.08*	12.3	8.81	15.8
TOTALS	14.85	100.0	6.08	-----	16.94	100.0	55.76	100.0

(1) Based on weekly samples from June 1967 through April 1968.
(2) Based on weekly composite samples from July 1967 through April 1968.
(3) Estimates based on five 8-hour composite samples, flow measurements and company supplied flow estimates.
& Nitrate and nitrite nitrogen were not run on samples from this plant.
* The total kjeldahl nitrogen loading is the same as the ammonia loading.

APPENDIX

A.7

Hillsborough Bay Technical
Assistance Project

Table A.7

CHEMICAL AND BACTERIOLOGICAL ANALYTICAL PROCEDURES

Parameter	Test Initially Used	Modification of Test	References
1. Dissolved Oxygen	Azide Modification of Iodometric Method	Floc settled only one time and acidified after 20 minutes, 300 ml sample automatically titrated with 0.038 N sodium thiosulfate	**Standard Methods for the Examination of Water and Wastewater.** 12th Ed., 1965.
2. Biochemical Oxygen Demand	Dilution Method	None	**Standard Methods.** 12th Ed., 1965.
3. Chemical Oxygen Demand	Dichromate Reflux Method with mercuric sulfate modification	50 ml of distilled water added to a weighed aliquot of 103°C dryed and ground benthic sample	1) **Standard Methods.** 11th Ed., 1960 2) Dobbs, R.A., Williams, R. T., "Elimination of Chloride Interference in the Chemical Oxygen Demand Test." **Analytical Chemistry**, Vol. 35, pp. 1064-7, 1963. 3) **Chemical Analytical Procedures.** Raritan Bay Project. 4) Finger, J. H., Wastler, T. A., "Organic Carbon-Organic Nitrogen Ratios of Sediments in a Polluted Estuary." Submitted for publication in **Journal Water Pollution Control Federation.**
4. Chloride	Mercuric Nitrate Method	pH of sample adjusted to 2 using 1N HNO_3, sample automatically titrated without indicator, 0.20000 N NaCl standard and 0.2000 N $Hg(NO_3)_2$ used	**Standard Methods.** 12th Ed., 1965.

Table A.7 (cont'd.)

Parameter	Test Initially Used	Modification of Test	References
5. pH	Glass Electrode Method	Fisher 13-639-90 combination electrode	**Standard Methods.** 12th Ed., 1965.
6. Total Suspended Solids and Volatile Suspended Solids	Gooch Crucible Method	Reeve angle glass fiber filter, 934 AH, size 2.4 cm employed	**Standard Methods.** 12th Ed., 1965.
7. Ammonia Nitrogen	Phenol-hypochlorite with sodium nitroprusside Technicon automated procedure	pH of sodium potassium tartrate adjusted to 6.0	1) Van Slyke, Donald, Hiller, Alma, "Determination of Ammonia in Blood." **J. Biol. Chem.**, Vol. 102, p. 499, 1933. 2) Russell, Jane, "The Colorimetric Estimation of Small Amounts of Ammonia by the Phenol-Hypochlorite Reaction." **J. Biol. Chem.**, Vol. 156, p. 457, 1944. 3) Lubochinsky, Bernard, Zalta, Jean Pierra, **Bull. Soc. Chim. Biol.**, Vol. 36, pp. 1363-6, 1954. 4) O'Brien, J. E., Fiore, Janece, "Ammonia Determination by Automatic Analysis." **Waste Engineering**, Vol. 33, p. 352, 1962. 5) Technicon Corporation information and flow diagram.
8. Nitrate-Nitrite Nitrogen	Cadium Reduction Sulfanilamide-Naphthyl-ethylenediamine Dihydrochloride Technicon Automated Procedure	None	Brewer, P. G., Riley, J. P., "The Automatic Determination of Nitrate in Sea Water." **Deep-Sea Res.**, Vol. 12, p. 765, 1965.

Table A.7 (cont'd.)

Parameter	Test Initially	Modification	References
9. Total Kjeldahl Nitrogen	Mercury-catalyzed Digestion followed with Phenol-hypochlorite Sodium Nitroprusside Technicon Automated Procedure	pH of 2 percent EDTA adjusted to 7.0 instead of 10.5 - 11.0	McDaniel, William H., Hemphill, Roy N., Donaldson, William T., "Automatic Determination of Total Kjeldahl Nitrogen in Estuarine Waters." Proceedings of Technicon Symposium, 1967, **Automation in Analytical Chemistry**, Vol. 1, p. 363-7.
10. Ortho and Total Phosphate	Persulfate Digestion with Ascorbic Acid-Molybdate Technicon Automated Procedure	None	1) Gales, Morris E., Jr., Julian, Elmo C., Kroner, Robert C., "Method for Quantitative Determination of Total Phosphorus in Water." **Journal American Water Works Association**, Vol. 58, No. 10, pp. 1363-8, Oct. 1966. 2) Murphy, J., Riley, J. P., "A Modified Single Solution Method for the Determination of Phosphate in Natural Waters." **Anal. Chim. Acta**, Vol. 27, p. 31, 1962. 3) Brewer, P.G., Chan, K.M., Riley, J.P., "Automatic Determination of Certain Micro-nutrients in Sea Water." Proceedings of Technicon Symposium, 1965, **Automation in Analytical Chemistry**, pp. 308-314.
11. Chlorophyll A, B and C	Richards and Thompson Method (Millipore Filtration)	None	1) Richards, Francis A., Thompson, Thomas G., "The Estimation and Characterization of Plankton Populations by Pigment Analysis. II. A Spectrophotomethric Method for the Estimation of Plankton Pigments." **Journal of Marine Research**. Vol. XI, No. 2, pp. 156 - 172, 1952.

Table A.7 (cont'd.)

Parameter	Test Initially Used	Modifications of Test	References
			2) Creitz, Grace I., Richards, Francis A., "The Estimation and Characterization of Plankton Populations by Pigment Analysis. III. A Note on the Use of 'Millipore' Membrane Filters in the Estimation of Plankton Pigments." **Journal of Marine Research.** Vol. XIV, No. 3, pp. 211-216, 1955.
12. Total Sulfide	Colorimetric Method	None	**Standard Methods.** 12th Ed., 1965.
13. Total Organic Carbon	Beckman Carbonaceous Analyzer	3 drops of concentrated HCl to approximately 20 ml of sample and purged for 5 minutes using nitrogen gas	1) Van Hall, C. E., Safranko, J., Stenger, V.A., "Rapid Method for the Determination of Organic Substances in Aqueous Solutions." **Analytical Chemistry**, Vol. 35, p. 315, 1963.
14. Rhodamine WT Dye	Fluorescence	Aminco Fluoro-microphotometer employed	1) Feuerstein, Donald L., Selleck, Robert, E., "Fluorescent Tracers for Dispersion Measurements." **Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers**, Vol. 89, No. SA4, August 1963.
15. Total Coliform	Membrane Filter Method with M-endo broth procedure	None	1) **Standard Methods.** 11th Ed., 1960. 2) **Recent Developments in Water Microbiology.** Short course conducted by Water Supply and Pollution Control Training Program, PHS, Robt. A. Taft Sanitary Engr. Center, Cinn., Ohio.

Table A.7 (cont'd.)

Parameter	Test Initially Used	Modifications of Test	References
16. Fecal Coliform	Membrane Filter Method with M-FC broth procedure	None	1) **Standard Methods.** 11th Ed., 1960. 2) **Recent Developments in Water Microbiology.** Short course conducted by Water Supply and Pollution Control Training Program, PHS, Robt. A. Taft Sanitary Engr. Center, Cinn., Ohio.

APPENDIX

A.8

Hillsborough Bay Technical
Assistance Project

Table A.8

FIELD SAMPLING PROCEDURES

Parameter	Type of Sampling Equipment	Sample Container	Sample Preservation in Field
Dissolved Oxygen	Kemmerer and/or Ohio River Sampler	Standard 300 ml Glass B.O.D. Bottle	Samples fixed in the field and stored in the dark on ice.
Biochemical Oxygen Demand	Kemmerer and/or Ohio River Sampler and/or submersible pump	Sealed Plastic Container	Samples stored in the dark on ice.
Bottom Sediments	Petersen Dredge	Sealed Plastic Containers	Samples stored in the dark on ice.
Chloride	Kemmerer and/or Ohio River Sampler and/or submersible pump	Sealed gallon Plastic Containers	None
pH	Kemmerer and/or Ohio River Sampler and/or submersible pump	Sealed Plastic Containers	Samples stored in the dark on ice.
Total Suspended, Volatile Suspended, or Total Residue	Kemmerer and/or Ohio River Sampler and/or submersible pump	Sealed Plastic Container	Samples stored in the dark on ice.
Nitrogen and Phosphorus	Kemmerer and/or Ohio River Sampler and/or submersible pump	Sealed Plastic Container	Samples stored in the dark on ice.

Table A.8 (cont'd.)

Parameter	Type of Sampling Equipment	Sample Container	Sample Preservation in Field
Chlorophyll	Kemmerer and/or Ohio River Sampler and/or submersible pump	Sealed Plastic Container	Samples stored in the dark on ice.
Total Sulfide	Kemmerer and/or Ohio River Sampler	Standard 300 ml Glass B.O.D. Bottle	Samples fixed in the field and stored in the dark on ice.
Total Organic Carbon	Kemmerer and/or Ohio River Sampler and/or submersible pump	Sealed Plastic Container	Samples stored in the dark on ice.
Rhodamine WT Dye	Submersible pump	Flint Glass Bottle	Samples stored in the dark on ice.
Total and Fecal Coliform	Kemmerer and/or Ohio River Sampler	Sterile Glass Bottle	Samples stored in the dark on ice.

APPENDIX

A.9

Hillsborough Bay Technical
Assistance Project

Table A.9

SAMPLING STATION DESCRIPTIONS

Station	Water Depth at MLW Ft.	Sample Depth Ft.	Station Description	Geographical Coordinates River Mile or Latitude Longitude
A1	10	Top @ 2 Bottom @ 8	Alafia River at U.S. Hwy. 41 Bridge, downstream side of bridge, mid-channel	River Mile - 0.9
A6	5	3	Station located on downstream side of Alafia River Bridge at Pinecrest - Lithia Road, mid-stream	River Mile - 16.2
B1	34	Top @ 5 Bottom @ 25	Hillsborough Bay at middle of the Garrison Turning Basin	27° 56' 22.0" 82° 27' 25.0"
B2	34	Top @ 5 Bottom @ 25	Hillsborough Bay at middle of the Ybor Turning Basin off N.E. corner of Seddon Island	27° 56' 30.0" 82° 26' 40.0"
B3	9	5	Hillsborough Bay at the west side of Davis Island, located 100 yards off the northernmost inlet	27° 55' 49.0" 82° 27' 48.0"
B4	34	Top @ 5 Bottom @ 25	Hillsborough Bay, Seddon Channel off north side of Davis Island Marina entrance, mid-channel	27° 55' 52.0" 82° 27' 11.0"
B5	34	Top @ 5 Bottom @ 25	Hillsborough Bay, Sparkman Channel at Buoy 3, mid-channel	27° 56' 03.0" 82° 26' 47.0"
B6	12	Top @ 2 Bottom @ 8	McKay Bay at 22nd Avenue Causeway Bridge, south side, mid-channel	27° 55' 58.0" 82° 25' 52.0"

Table A.9 (cont'd.)

Station	Water Depth at MLW Ft.	Sample Depth Ft.	Station Description	Geographical Coordinates River Mile or Latitude Longitude
B7	34	Top @ 5 Bottom @ 25	Hillsborough Bay at the intersection of Sparkman and Seddon Channels, approximately 100 yards off the tip of Seddon Island	27° 55' 24.0" 82° 26' 53.0"
B8	9	5	Hillsborough Bay, 700 yards east of Bayshore Boulevard on range between red brick apartment house and power plant	27° 54' 18.0" 82° 29' 01.0"
B9	12	5	Hillsborough Bay, 300 yards off the southern tip of Davis Island, 200 yards east of a line extended from the western side, between two boat docks	27° 54' 20.0" 82° 27' 40.0"
B10	34	Top @ 5 Bottom @ 25	Hillsborough Bay, Cut "C" and Port Sutton Channels, between markers "2" and "31", mid-channel	27° 54' 04.0" 82° 26' 20.0"
B11	9	5	Hillsborough Bay, 300 yards off Tampa Yacht Club, even with end of fishing pier on Ballast Point	27° 53' 07.0" 82° 28' 40.0"
B12	34	Top @ 5 Bottom @ 25	Hillsborough Bay, Cut "C" Channel, between Buoys "28" and "29", mid-channel	27° 53' 03.0" 82° 26' 27.0"
B13	6	2	Hillsborough Bay, 1600 yards off the mouth of Archie Creek, about 3000 yards south of round silos at Port Sutton	27° 52' 52.0" 82° 25' 00.0"

Table A.9 (cont'd.)

Station	Water Depth at MLW Ft.	Sample Depth Ft.	Station Description	Geographical Coordinates River Mile or Latitude Longitude
B14	10	5	Hillsborough Bay, MacDill Air Force Base port facility, MacDill Channel between buoys "6" and "7", mid-channel	27° 51' 33.0" 82° 28' 30.0"
B15	34	Top @ 5 Bottom @ 25	Hillsborough Bay, Cut "C" Channel, between Buoys "24" and "25", mid-channel	27° 51' 40.0" 82° 26' 35.0"
B16	6	3	Hillsborough Bay, 900 yards west of U.S. Phosphoric Products Plant, north of the Alafia River Channel	27° 51' 43.0" 82° 24' 44.0"
B17	10	5	Hillsborough Bay, west shore, off MacDill Air Force Base, 25 yards due east of rear Alafia River range marker	27° 50' 29.0" 82° 27' 46.0"
B18	34	Top @ 5 Bottom @ 25	Hillsborough Bay, intersection of Cut "C" and Alafia River Channels, mid-channel	27° 50' 42.0" 82° 26' 40.0"
B19	25	Top @ 5 Bottom @ 20	Hillsborough Bay, Alafia River Channel between Buoys "7" and "6", mid-channel	27° 50' 55.0" 82° 25' 28.0"
B20	25	Top @ 5 Bottom @ 20	Hillsborough Bay, Alafia River Channel between Buoys "11" and "12", mid-channel	27° 51' 05.0" 82° 24' 34.0"
B21	5	3	Hillsborough Bay, 1000 yards west of Gardenville Beach, near double markers of south channel of Alafia River	27° 50' 25.0" 82° 24' 13.0"

Table A.9 (cont'd.)

Station	Water Depth at MLW Ft.	Sample Depth Ft.	Station Description	Geographical Coordinates River Mile or Latitude Longitude
B22	34	Top @ 5 Bottom @ 25	Hillsborough Bay, Cut "C" Channel, between Buoys "13" and "14", mid-channel	27° 48' 53.0" 82° 26' 53.0"
B23	34	Top @ 5 Bottom @ 25	Tampa Bay, off tip of Interbay Peninsula at intersection of Cut "F", Cut "G" and Gadsden Channels, between Buoys "7" and "8"	27° 46' 58.0" 82° 31' 24.0"
B24	4	2	Hillsborough Bay, on range between old hotel and southern point of Davis Island, about 350 yards offshore from Bayshore Boulevard	27° 53' 41.0" 82° 28' 22.0"
B25	25	Top @ 5 Bottom @ 20	Located in Alafia River Channel, adjacent to Buoy "15", mid-channel	River Miles - 0.3
B26	12	5	Hillsborough Bay, 1200 yards south of entrance to Davis Island seaplane basin on range from power plant on Port Sutton to Ballast Point	27° 53' 54.0" 82° 27' 12.0"
H1	10	Top @ 2 Bottom @ 8	Hillsborough River at the Buffalo Avenue Bridge, downstream side, mid-channel	River Mile - 3.6
H2	30	Top @ 5 Bottom @ 25	Located immediately above main gate on right side of Tampa City Water Supply Reservoir Dam on the Hillsborough River	River Mile - 10.0
P1	2	1	Palm River, U.S. Hwy. 41 Bridge, downstream side of bridge, mid-channel	River Mile - 0.7

Table A.9 (cont'd.)

Station	Water Depth at MLW Ft.	Sample Depth Ft.	Station Description	Geographical Coordinates River Mile or Latitude Longitude
P1-A	4	2	Palm River, downstream side of ACL Railroad Bridge, mid-stream	River Mile - 1.0
P2	2	1	Palm River, upstream side of S.R. 574 Bridge, mid-stream	River Mile - 4.0

APPENDIX

A.10

Hillsborough Bay Technical Assistance Project

BENTHIC CHARACTERIZATION STUDY

Table A.10

Analytical Results

Station	Date	Total Phosphate % by wt.	Total Kjeldahl Nitrogen % by wt.	Organic Carbon % by wt.	OC/ON	T.O.D. mg/g
A1	1-29-68	1.61	0.082	1.15	14.0	34
B1	1-16-68	1.88	0.380	6.82	17.9	200
B2	1-16-68	1.38	0.215	3.09	14.4	92
B3	1-18-68	0.12	0.073	3.31	45.3	92
B3-0	1-18-68	0.04	0.027	0.19	7.0	6
B3-1	1-18-68	0.04	0.021	0.14	6.7	5
B4	1-16-68	2.95	0.320	4.02	12.6	122
B5	1-15-68	1.23	0.214	4.17	19.5	121
B7	1-15-68	1.32	0.235	3.77	16.0	110
B8	1-22-68	1.10	0.158	1.72	10.9	53
B8-0	1-22-68	0.25	0.158	0.22	1.4	13
B8-1	1-22-68	1.15	0.026	0.40	15.4	12
B8-2	1-22-68	1.18	0.037	3.31	89.4	90
B8-3	1-22-68	1.18	0.161	3.33	20.7	96
B9	1-22-68	1.34	0.029	3.62	124.8	98
B10	1-16-68	0.73	0.105	1.59	15.1	47
B11	1-23-68	0.08	0.029	0.22	7.6	7
B11-0	1-23-68	0.06	0.044	0.06	1.4	4
B11-1	1-23-68	1.35	0.206	2.32	11.3	71
B11-2	1-23-68	1.37	0.207	2.62	12.6	79
B11-3	1-23-68	1.34	0.214	2.30	10.7	71
B11-4	1-23-68	1.55	0.186	2.20	11.8	67
B11-5	1-23-68	0.51	0.068	0.45	6.6	15
B12	1-23-68	0.20	0.03	0.45	15.0	13
B13	1-23-68	0.08	0.023	0.22	9.6	7
B14	1-22-68	1.48	0.418	4.88	11.7	149
B14-0	1-22-68	0.07	0.037	0.23	6.2	8
B14-1	1-22-68	1.38	0.297	4.10	13.8	123
B14-2	1-22-68	1.46	0.363	4.84	13.3	146
B14-3	1-22-68	0.81	0.138	1.51	10.9	47
B14-4	1-22-68	0.32	0.059	0.52	8.8	16
B15	1-22-68	0.24	0.054	0.59	10.9	18
B16	1-22-68	0.63	0.075	0.84	11.2	25
B17	1-23-68	1.10	0.336	4.30	12.8	130
B17-0	1-23-68	0.10	0.075	0.52	6.9	17
B17-1	1-23-68	0.22	0.088	0.62	7.0	20
B17-2	1-23-68	0.39	0.029	0.29	10.0	10
B17-3	1-23-68	1.06	0.143	1.66	11.6	51
B17-4	1-23-68	0.34	0.048	0.51	10.6	16
B18	1-29-68	0.39	0.014	0.10	7.1	3

Table A.10 (cont'd.)

Station	Date	Total Phosphate % by wt.	Total Kjeldahl Nitrogen % by wt.	Organic Carbon % by wt.	OC/ON	T.O.D. mg/g
B19	1-29-68	------	0.411	4.75	11.6	145
B20	1-29-68	2.48	0.352	4.06	11.5	124
B21	1-23-68	0.24	0.025	0.24	9.6	8
B22	1-23-68	0.21	0.110	0.44	4.0	17
B22-0	1-23-68	0.03	0.02	0.21	10.5	6
B22-1	1-23-68	0.32	0.102	0.92	9.0	29
B22-2	1-23-68	0.31	0.053	0.86	16.2	25
B22-3	1-23-68	0.08	0.018	0.14	7.8	4
B23	1-24-68	0.74	0.252	2.65	10.5	82
B25	1-29-68	4.97	0.27	3.83	14.2	115
C1	1-16-68	1.35	0.216	3.77	17.4	110
D1	1-15-68	1.12	0.192	2.65	13.8	80
D2	1-16-68	1.70	0.328	3.79	11.6	116
D3	1-22-68	1.94	0.279	3.27	11.7	100
DIB	1-30-68	0.82	0.258	5.48	21.2	158
Hospital	1-30-68	0.22	0.061	1.52	24.9	43
LDI-0	1-22-68	0.06	0.01	0.12	12.0	4
LDI-1	1-22-68	0.22	0.145	0.47	3.2	19
LDI-2	1-22-68	0.78	0.267	3.81	14.3	114
Mac 0-0	1-29-68	0.07	0.035	0.24	6.8	8
Mac 0-1	1-30-68	0.06	0.023	0.18	7.8	6
Mac 0-2	1-30-68	0.06	0.019	0.21	11.0	6
Mac 0-3	1-30-68	0.18	0.026	0.18	6.9	6
Mac 0-4	1-30-68	0.98	0.292	2.97	10.2	92
Mac 1-1	1-29-68	1.13	0.352	3.78	10.7	117
Mac 1-2	1-29-68	1.13	0.318	3.80	11.9	117
Mac 2-1	1-29-68	0.68	0.142	1.84	13.0	56
Mac 2-2	1-29-68	0.65	0.145	2.03	14.0	61
Mac 2-3	1-29-68	0.36	0.076	1.02	13.4	31
Mac 2-4	1-29-68	0.15	0.027	0.23	8.5	7
Mac 3-1	1-29-68	0.07	0.018	0.19	10.6	6
Mac 3-2	1-29-68	0.20	0.046	0.54	11.7	16
Mac 3-3	1-29-68	0.18	0.04	0.36	9.0	11
Mac 3-4	1-30-68	0.20	0.026	0.26	10.0	8
Mac 4-1	1-30-68	0.17	0.079	0.55	7.0	18
Mac 4-2	1-30-68	0.10	0.054	0.35	6.5	12
Mac 4-3	1-30-68	0.38	0.120	1.48	12.3	45
Mac 4-4	1-30-68	0.44	0.048	0.18	3.8	7
Platt St.	1-30-68	0.72	0.09	1.38	15.3	41
TSTP 0-0	1-15-68	1.72	0.280	3.67	13.1	110
TSTP 0-1	1-15-68	1.94	0.055	0.96	17.4	28
TSTP 0-2	1-15-68	1.48	0.259	3.22	12.4	98
TSTP 0-3	1-15-68	1.71	0.208	2.64	12.7	80
TSTP 1-1	1-15-68	1.22	0.231	2.63	11.4	81
TSTP 1-2	1-15-68	1.79	0.289	3.98	13.8	119
TSTP 1-3	1-15-68	1.73	0.281	3.51	12.5	106

Table A.10 (cont'd.)

Station	Date	Total Phosphate % by wt.	Total Kjeldahl Nitrogen % by wt.	Organic Carbon % by wt.	OC/ON	T.O.D. mg/g
TSTP 1-4	1-15-68	1.95	0.311	4.25	13.7	128
TSTP 2-1	1-18-68	1.68	0.428	2.73	6.4	92
TSTP 2-2	1-18-68	1.66	0.335	5.18	15.5	154
TSTP 2-3	1-18-68	1.28	0.181	2.40	13.2	72
TSTP 2-4	1-18-68	0.20	0.041	0.76	18.5	22
TSTP 3-1	1-15-68	1.60	0.327	4.39	13.4	132
TSTP 3-2	1-15-68	1.62	0.406	5.66	13.9	170
TSTP 4-1	1-16-68	0.52	0.114	0.96	8.4	31
TSTP 4-2	1-16-68	1.55	0.257	3.54	13.8	106

APPENDIX

A.11

Hillsborough Bay Technical Assistance Project

Table A.11

FECAL COLIFORM DATA*

Station	Maximum F. Coliform/100 ml	Minimum F. Coliform/100 ml	Logarithmic Mean F. Coliform/100 ml
A1T	1,550	5	62
A1B	1,830	1	22
B1T	470	56	260
B1B	3,360	10	190
B2T	6,900	53	270
B2B	2,500	28	240
B3	180	0	22
B4T	800	59	270
B4B	3,230	33	460
B5T	1,080	47	260
B5B	2,200	22	330
B6T	27,000	2	980
B6B	46,000	2	310
B7T	2,400	140	620
B7B	6,700	6	1030
B8	1,900	0	25
B9	20,000	0	1560
B10T	106,000	73	5240
B10B	4,900	7	410
B11	430	2	6
B12T	107,000	1	350
B12B	310	0	20
B13	8	0	2
B14	780	2	6
B15T	13,100	0	18
B15B	100	0	16
B16	700	0	6
B17	1,540	0	4
B18T	5,600	0	8
B18B	61	0	3
B19T	36	0	4
B19B	108	0	5
B20T	550	0	10
B20B	8	0	2
B21	200	0	2
B22T	5	0	2
B22B	30	0	2
B23T	3	0	1
B23B	9	0	1
B24	400	0	26

* Weekly Data

APPENDIX

A.12

Hillsborough Bay Technical Assistance Project

Table A.12

Planning and Scheduling Projections

PROBLEM

Obnoxious odors and poor water quality with respect to organic material have been occurring since 1928 along the western shore of the Bay. Previous reports have emphasized the high nutrient content in the Bay and the growth and decay of fixed algae along the western shore. Recreational uses along the western shore, both land and water based, have been foregone due to this problem.

OBJECTIVES

A) To identify and quantify key sources of wastes in Hillsborough Bay and determine their effects on water quality and uses.

B) To determine the cause or causes of noxious odors in Hillsborough Bay.

C) To recommend means of modifying conditions in Hillsborough Bay to eliminate causes of odors and make possible other desired uses.

PLANNING HYPOTHESES

Odors and poor water quality in Hillsborough Bay are assumed to result principally from one or a combination of:

A) Uprooting and subsequent decay of fixed aquatic plants.

B) Oxygen depletion in waters overlying organic bottom deposits.

C) Satisfaction of soluble organic material.

NECESSARY STUDIES

A) Literature review.

B) Hydrological analysis of expected frequency and magnitude of in-flow from tributary streams and rainfall - collection of data during survey period.

C) Inventory and sampling of all significant discrete waste sources.

D) Biological survey to determine area and mass of standing crop of both fixed and planktonic algae - short term steady state and long term monitoring.

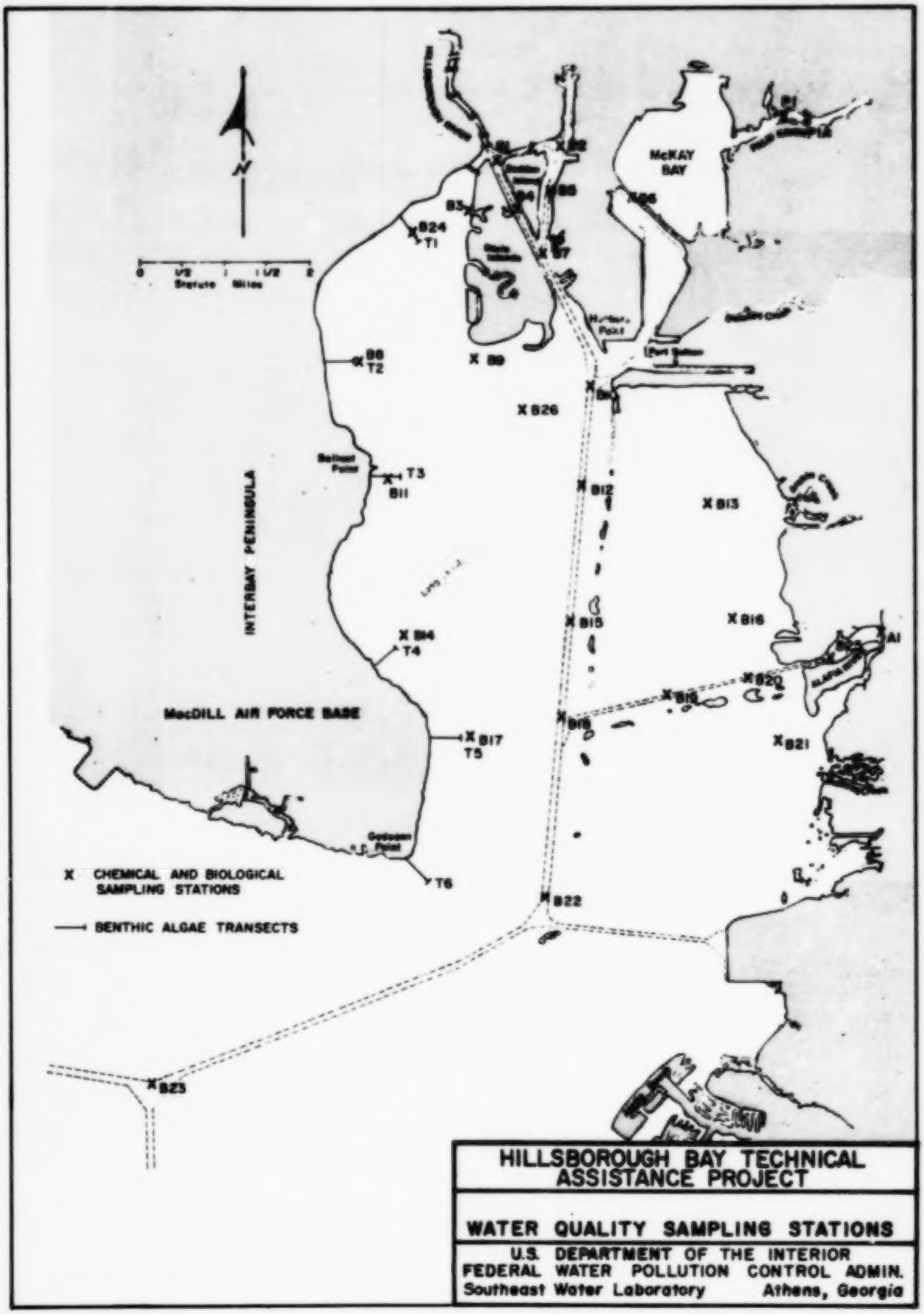
E) Comparative biological survey of unpolluted area subject to a similar environment.

F) Laboratory exposure of fixed algae to different environmental conditions to determine if odor is produced when it decays under controlled conditions.

OBJECTIVE B
OBJECTIVE A
HYPOTHESIS A

Table A.12 (cont'd.)

OBJECTIVE B	OBJECTIVE A	HYPOTHESIS B	G) Field survey to identify and map areas of organic benthic deposits - evaluation of oxygen uptake rate of benthic deposits under field and laboratory conditions.
		HYPOTHESIS C	H) Short-term intensive survey to define critical water quality conditions in Hillsborough Bay.
			I) Long-term monitoring water quality surveys to minimize the localized effects of unsteady state conditions and to define changes with changes in environmental conditions.
			J) Circulation studies to define distribution of fresh water and soluble organic materials.
			K) Establishment of an odor panel to qualitatively relate the results of the previous studies to the occurrence of odors.
OBJECTIVE C		HYPOTHESIS B & C	**ANALYSIS OF DATA** A) Mathematical model - relationship between systems shown by mathematical equations simulating the mechanism of cause and effect. This approach will hopefully evaluate the relative effects of soluble organic material discharged from waste sources, benthic organic deposits and physical characteristics of the Bay on indicator water quality parameters such as chlorides and dissolved oxygen.
		HYPOTHESIS A & C	B) Statistical approach - through the use of multiple regression and correlation techniques, an attempt will be made to demonstrate cause and effect relationships between dependent variables such as water quality parameters or biological productivity and standing crop, and environmental factors which may affect them.


N
0 1/2 1 1 1/2 2
Statute Miles
B1
B2
B3
B4
B5
B7
B24
T1
McKAY BAY
Port Sutton
B8
T2
X B9
B10
X B26
Ballast Point
T3
B11
B12
X B13
INTERBAY PENINSULA
X B14
T4
B15
X B16
A1
B20
B19
B18
MacDILL AIR FORCE BASE
X B17
T5
X B21
Gadsden Point
T6
B22
B23
X CHEMICAL AND BIOLOGICAL SAMPLING STATIONS
BENTHIC ALGAE TRANSECTS

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

WATER QUALITY SAMPLING STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Water Laboratory Athens, Georgia

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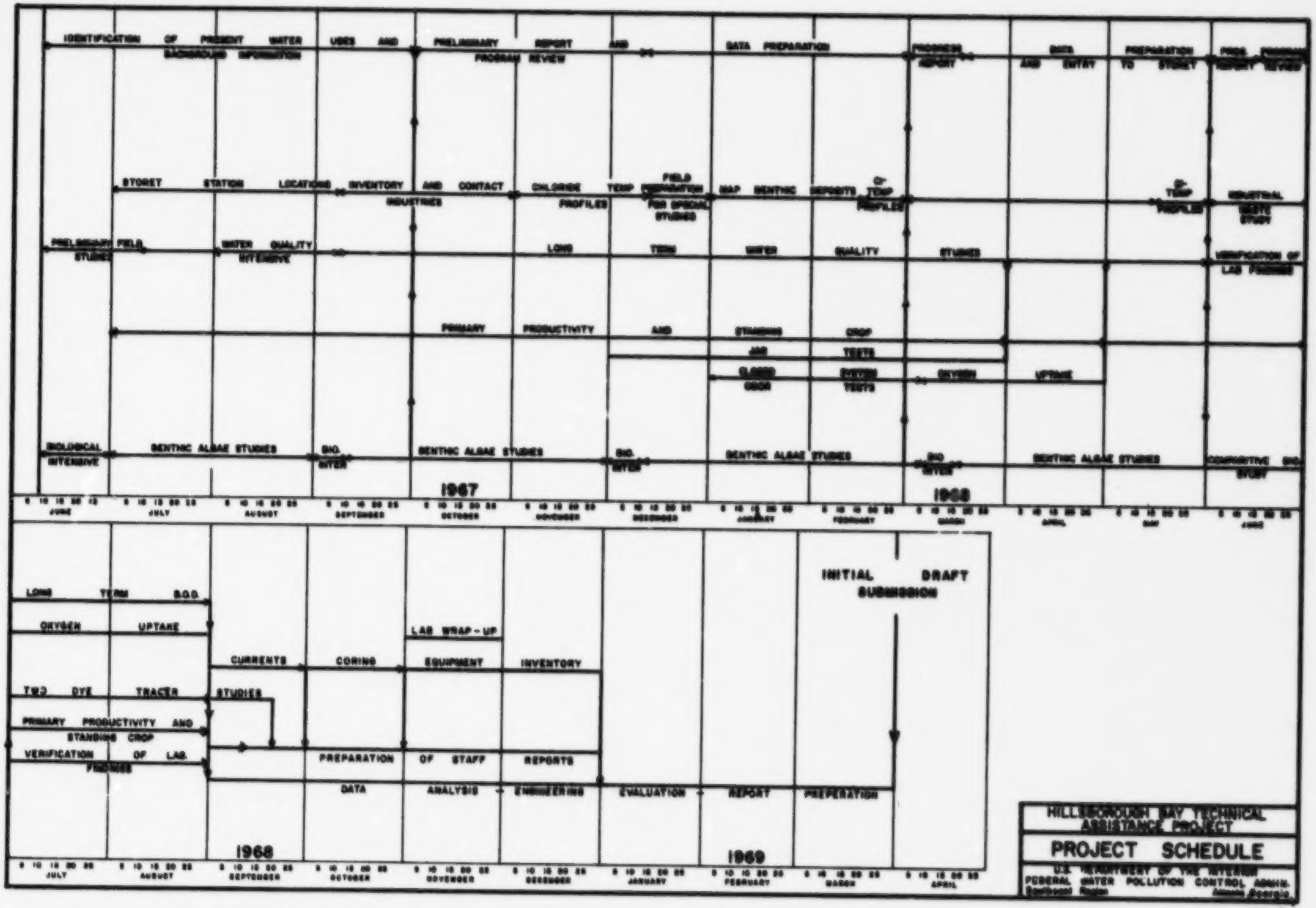

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT

PROJECT SCHEDULE

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMIN.
Southeast Region Atlanta, Georgia

HILLSBOROUGH BAY TECHNICAL ASSISTANCE PROJECT
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Laboratory Director	James H. Finger
Operations Engineer	M. Doug Lair
Biologist	Reginald G. Rogers
Chemist	Raymond P. Lawless
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Marine Mechanic	Donald W. Lawhorn
Secretary	Barbara A. Carson
Biological Aide	John Hall
Laboratory Aide	Roger Stewart
Aquatic Sampler	Thomas E. McGacken